
**PROJECT DESCRIPTION
AND UPDATED COST ESTIMATES
FOR SITES/COLUSA RESERVOIR PROJECT**

**Prepared by the CALFED Storage and Conveyance Refinement Team
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INTRODUCTION

The *Project Description and Updated Cost Estimates for Sites/Colusa Reservoir Project* report has been prepared as part of the Storage and Conveyance Component Refinement Task of the CALFED Bay-Delta Program (CALFED or Program). CALFED's mission is to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) system.

This report summarizes the principal features, estimated costs, and environmental considerations of constructing the Sites/Colusa Reservoir Project. The geography of the site permits a range of storage options to be considered, from a minimum of approximately 1.2 million acre-feet (maf) to a maximum of 3.3 maf. The general location of the Sites/Colusa Reservoir Project is shown on Figure 1. This evaluation and others that are being performed by CALFED are intended to provide a facilities evaluation and updated cost estimates of representative storage and conveyance components. The objectives of the Sites/Colusa Reservoir Project evaluation are (1) to provide updated cost estimates for the three project alternatives which represent costs within the range expected if the project were to be constructed today and (2) to enable CALFED to compare this project against other projects that might be considered as part of a long-term CALFED solution strategy.

The cost estimates for the Sites/Colusa Reservoir Project were developed by applying current unit costs to quantities found in the following three reports: the 1964 and 1980 U.S. Bureau of Reclamation's reconnaissance and appraisal reports on the West Sacramento Canal Unit and the California Department of Water Resources' (DWR) 1996 *Reconnaissance Survey: Sites Offstream Storage Project*.

A preliminary evaluation of the environmental considerations associated with this proposed project has also been included in this report. Fish, wildlife, plant, and cultural resources that

could be affected have been described and potential impacts have been identified. The information for the evaluation of environmental considerations was gathered from existing literature and databases.

PROJECT BACKGROUND

Various Sites/Colusa Reservoir Projects have been examined over the past four decades. The earliest published reference to a Sites Reservoir Project is found in the DWR Bulletin 3, *The California Water Plan 1957*, which mentions a 48,000 acre-foot off-stream storage reservoir on Stone Corral and Funks Creeks supplied by the Tehama-Colusa Canal. The project was again identified in DWR Bulletin 109, *Colusa Basin Investigation*, 1964, to evaluate potential flood control projects, and considered two separate reservoirs of 5,800 and 7,600 acre-feet on Stone Corral and Funks Creeks, respectively. An update of this report in 1990 found these reservoirs unjustified for flood control alone.

Consideration of larger projects at the Sites location was first documented in December 1964, when the Bureau of Reclamation published its *West Sacramento Canal Unit Report*, which studied the feasibility of extending the Tehama-Colusa Canal (via a new West Sacramento Valley Canal) into Solano County near Fairfield. As part of this canal extension plan, a 1.2 maf Sites Reservoir was proposed. This study did not evaluate the potential of Sites Reservoir as a stand-alone project, only as part of the extended canal system. This was the most detailed study of the Sites Reservoir Project and formed the basis for cursory studies which followed. The Bureau of Reclamation attempted to obtain funds for a full feasibility study of Sites Reservoir in 1977; however, appropriations were never approved. The short concluding report ending the Bureau of Reclamation's efforts stated, "The 1976-77 Drought clearly demonstrated the need for additional surface water development. One means of increasing water supply is conservation of surplus flows by storage in off-stream reservoirs." Sites Reservoir is capable of conserving these surplus flows, thereby increasing water supply availability.

Throughout the 1960s and 1970s, Sites Reservoir has historically been considered a Bureau of Reclamation project, and DWR's only published report on the project was for a small-scale flood control project. However, DWR performed unpublished analyses of the larger Colusa Reservoir Project's water supply potential in connection with regional investigations. In DWR Bulletin 136, *Northern Coastal Area Investigation*, various conveyance routes were studied including a westside conveyance system which included Colusa Reservoir. Two unpublished office reports in 1967 and 1968 on the Klamath-Trinity Development Projects included conveyance systems which terminated at Colusa Reservoir. In 1975, a DWR progress report titled *Major Surface Water Development Opportunities in the Sacramento Valley* contained details of a Colusa Project. A slightly modified version of the Colusa Reservoir plan is shown in DWR Bulletin 76-81 (November 1981), *State Water Project - Status of Water Conservation and Water Supply Augmentation Plans*. This DWR report states that studies of Colusa Reservoir to date indicated that the incremental cost of storage would be excessive in comparison to storage costs of Sites Reservoir.

In September 1980, a Bureau of Reclamation report titled *West Sacramento Canal Unit, Appraisal Design Criteria and Cost Estimate Appendix* reanalyzed the West Sacramento Canal Unit features including a Sites Reservoir at a capacity of 1.9 maf. This report was adopted as a basis for the Large Sites Reservoir (1.9 maf) cost estimate.

Sites and Colusa Reservoirs are contained in an August 1982 unpublished DWR office report titled *Enlarging Shasta Lake Feasibility Study - Descriptions of Alternative Storage Facilities*. This report relied on previous studies and did not develop any new information. Likewise, information on the Sites or Colusa Projects is contained in the following reports prepared since 1982; all are based on previously developed information: (1) *Enlarging Shasta Lake Feasibility - Progress Report*, USBR-DWR Unpublished Draft, November 1983; (2) *Assessment of Bureau of Reclamation Planning Activities Involving New Water Supplies*, Limited USBR

Office Report, September 1983; (3) *Least-Cost CVP Yield Increase Plan - Appendix #6, Surface Storage and Conveyance*, USBR Office Report, September 1995.

In March 1990, the engineering consulting firm, CH2M Hill, Inc., prepared a long-range plan for Glenn-Colusa which included an 870,000 acre-foot Sites Reservoir with normal water surface elevation at 460 feet. This project was based on the Bureau of Reclamation's 1964 report, but was judged unimplementable by Glenn-Colusa because of the financing needed to cover the capital cost of \$152 million. In 1993, CH2M Hill published a small report on *Meeting California's Water Needs in the 21st Century*, which presented a conceptual Westside Storage and Conveyance System. This concept mentioned a Sites/Colusa Reservoir with a feeder pipeline from Lake Oroville. DWR's *California Water Plan Update*, Bulletin 160-93, included a description of the Westside Sacramento Valley Concept when discussing water supply management options.

FACILITIES DESCRIPTIONS

This section provides details on three alternative sizes of off-stream storage projects at the Sites/Colusa location to be used for this evaluation. These sizes include (1) the Small Sites Reservoir Project, which would have a capacity of 1.2 maf with the crest of the dam at 490 feet above mean sea level (MSL); (2) the Large Sites Reservoir Project, with a capacity of 1.9 maf with the crest of the dam at 541 feet above MSL; and (3) the Colusa Reservoir Project, with a capacity of 3.3 maf with the crest of the dam at 541 feet above MSL. Other intermediate sizes are possible, but these three alternatives encompass the practical range of reservoir sizes for large-scale water conservation purposes. If the storage of Colusa Reservoir was increased above 3.3 maf, the embankment volume and number of saddle dams would increase substantially. Additionally, seepage through Logan Ridge, which forms the eastern boundary of all reservoir options, might become an issue.

PROJECT LOCATION

The Sites/Colusa Reservoir Project would be located about 10 miles west of Maxwell in Antelope Valley across the drainages of Stone Corral and Funks Creeks. The main dams and most of the project would lie within northern Colusa County, but a Colusa Reservoir would extend into southern Glenn County. The Colusa Reservoir Project would be formed by extending the Large Sites Reservoir north into the Hunters and Logan Creek drainages. Figure 2 shows the general location of the facilities associated with the Sites Reservoir projects. Figure 3 shows the general location of the facilities associated with the Colusa Reservoir project.

PROJECT DESCRIPTION

All of these projects are off-stream storage reservoirs as they have very little natural runoff and would have to be filled primarily through pumped diversions from the Sacramento River. The Tehama-Colusa Canal and Glenn-Colusa Irrigation District Canal are the main existing conduits through which a Sites/Colusa Reservoir Project could be filled. An alternative option for filling these reservoirs would be a new diversion from the Sacramento River, near Chico Landing, which would tie into the Tehama-Colusa Canal. Similar evaluations for increasing the capacity of the Tehama-Colusa Canal or the Glenn-Colusa Canals and constructing a new Sacramento River diversion and conveyance facility (Chico Landing Intertie) are being performed by CALFED.

The Small and Large Sites Reservoir Projects would be formed by constructing two main dams on Stone Corral and Funks Creeks and several smaller saddle dams along the low divide between the Funks and Hunters Creek drainages. The larger Colusa Reservoir Project would be formed by constructing two additional large dams on Hunters and Logan Creeks. Several additional saddle dams would also be required; the overall increase in dam volume required for the Colusa Reservoir Project compared to the Large Sites Reservoir Project is almost threefold. Area-

capacity curves for Sites Reservoir and Colusa Reservoir are shown on Figures 4 and 5, respectively.

The primary purpose of the Sites/Colusa Reservoir Project would be to provide additional drought-year water supplies for agricultural, environmental, and urban uses in the Bay-Delta. In addition, other potential benefits of a Sites/Colusa Reservoir Project could include:

- Flood control for the lands around the town of Maxwell as well as in the Colusa Basin drain.
- Increased recreational use around the reservoir.
- Increased reliability of local water supplies.
- Potential for conjunctive use and management of local groundwater and surface water supplies to further augment drought period water supplies.
- More reliable and adequate water supplies for refuges in the Colusa Basin.

PRINCIPAL FACILITIES

The following section provides a description of the three alternative reservoirs which could be constructed at the Sites/Colusa site. These reservoirs are the Small Sites Reservoir with 1.2 maf of total storage capacity, the Large Sites Reservoir with 1.9 maf of total storage capacity, and the Colusa Reservoir with 3.3 maf of total storage capacity.

Summaries of the physical features of the Small Sites, Large Sites, and Colusa Reservoir alternatives are provided in the following sections. A schematic profile of the Small Sites and

Large Sites alternatives is shown on Figure 6. A separate schematic profile of the Colusa Reservoir alternative is provided on Figure 7. In addition, Table 1 provides a summary of the physical characteristics of the Small and Large Sites and Colusa Reservoir Projects.

Small Sites Reservoir Project

The maximum operating water surface elevation would be at 480 feet above MSL and would inundate approximately 12,300 acres. The Small Sites Reservoir would be formed by a 251-foot-high Golden Gate Dam on Funks Creek and a 243-foot-high Sites Dam on Stone Corral Creek, supplemented by five rolled-earth dikes ranging from 10 to 80 feet high. The total storage capacity of the Small Sites Reservoir would be 1.2 maf.

The existing 40-foot-high dam which forms Funks Reservoir would remain the same for this alternative and would regulate inflow to and outflow from Sites Reservoir. A pumping-generating plant would be located at the base of Golden Gate Dam to pump water a maximum of 280 feet from Funks Reservoir into Sites Reservoir (Sites Pumping-Generating Plant). The pumping-generating plant would have a capacity of 5,000 cubic feet per second (cfs) and would serve both inflow and outflow requirements for the Small Sites Reservoir Project.

A small open-chute type spillway with an uncontrolled crest (ungated) and a capacity of 250 cfs would discharge into a tributary of Hunters Creek at the northwest corner of the reservoir. Because of the small, relatively dry tributary drainage area and large reservoir surface area, a small spillway would be adequate to handle maximum probable project flood.

The outlet tunnel, located on the right abutment of Golden Gate Dam, would contain the penstock for the Sites Pumping-Generating Plant. The outlet tunnel would be used to fill Sites Reservoir and to make releases to Funks Reservoir either through the pumping-generating plant or a bypass. DWR's Division of Safety of Dams requires that during emergency evacuation,

10 percent of the maximum water depth must be released in ten days. Therefore, the Small Sites Reservoir outlet tunnel was cost-estimated at a release capacity of 15,200 cfs. No outlet facility would be required at Sites Dam. Funks Reservoir has a spillway with a capacity of 22,430 cfs and, therefore, no additional emergency release facilities are required at Funks Reservoir to evacuate the emergency release from Small Sites Reservoir.

Large Sites Reservoir Project

The Large Sites Reservoir Project was described and evaluated in the 1980 Bureau of Reclamation appraisal report on the West Sacramento Canal Unit. Similar in content to the 1964 report, the 1980 report also focused on the West Sacramento Canal Unit components, one of which was Large Sites Reservoir.

The Large Sites Reservoir Project has a maximum operating water surface elevation of 532 feet, which would inundate approximately 14,700 acres. The reservoir would be formed by a 294-foot-high Sites Dam on Stone Corral Creek and a 302-foot-high Golden Gate Dam on Funks Creek (plus 12 saddle dams ranging up to 112 feet high). The total storage capacity of the Large Sites Reservoir would be 1.9 maf.

The existing 40-foot-high dam which forms Funks Reservoir would remain the same for this alternative and would regulate inflow and outflow from Sites Reservoir. A pumping-generating plant would be located at the base of Golden Gate Dam to pump water a maximum of 332 feet from Funks Reservoir into Sites Reservoir (Sites Pumping-Generating Plant). The pumping-generating plant would have a capacity of 5,000 cfs and would serve both inflow and outflow requirements for the Large Sites Reservoir Project.

Twelve saddle dams ranging in height from 27 to 112 feet would be required at the north end of Large Sites Reservoir to close the gaps between the small rolling mounds that form the divide

between the Funks and Hunters Creek drainages. A small open-chute type spillway with an uncontrolled crest (ungated) and a capacity of 250 cfs would discharge into a tributary of Hunters Creek at the northwest corner of the reservoir next to the westernmost saddle dam. Because of the small, relatively dry, tributary drainage area and large reservoir surface area, a small spillway would be adequate.

The outlet tunnel, located on the right abutment of Golden Gate Dam, would contain the penstock for the Sites Pumping-Generating Plant. The outlet tunnel would be used to fill Sites Reservoir and to make releases to Funks Reservoir, either through the pumping-generating plant or a bypass. To satisfy the DWR, Division of Safety and Dams requirement that during emergency evacuation, 10 percent of the maximum water depth must be released in ten days, the outlet tunnel was cost-estimated at a release capacity of 22,000 cfs. Like Small Sites Reservoir, no outlet facility would be required at Sites Dam, and no additional emergency release facilities are required at Funks Reservoir to evacuate the emergency release from a Large Sites Reservoir.

Colusa Reservoir Project

The extension of the Large Sites Reservoir into the northern "Colusa compartment" would form the Colusa Reservoir. In addition to the 294-foot-high Sites Dam and the 302-foot-high Golden Gate Dam, it would be necessary to build two additional large dams where Hunters and Logan Creeks pass through Logan Ridge, Hunter Dam and Logan Dam, respectively. Hunters Dam would be 282 feet high and Logan Dam would be 272 feet high. Four small saddle dams ranging from 71 to 260 feet (maximum dam heights) would be required along Logan Ridge, and five saddle dams ranging from 11 to 130 feet (maximum dam heights) would be required along the northern boundary of Colusa Reservoir. The maximum operating water surface elevation would be at 532 feet MSL, which would inundate approximately 29,600 acres. The total storage capacity of Colusa Reservoir would be 3.3 maf.

The Colusa Reservoir, like Small and Large Sites Reservoirs, would be filled by winter and spring Sacramento River surplus flows. This water would be delivered to Colusa Reservoir through an enlarged Tehama-Colusa Canal, but would be pumped from a different location than that of Small and Large Sites Reservoirs. This location is approximately four miles south of Willows and nine miles north of Funks Reservoir.

The conveyance system from the Tehama-Colusa Canal to Colusa Reservoir would include (1) Logan Forebay, a 400 acre-foot impoundment formed by a low earth dam on Logan Creek immediately west of the Tehama-Colusa Canal; (2) a 5,000 cfs, 1.7-mile Logan Canal connecting Logan Forebay to the Logan Pumping-Generating Plant located at the base of Logan Dam; and (3) the Logan Pumping-Generating Plant, which would lift water a maximum of 322 feet into Colusa Reservoir. Logan Pumping-Generating Plant would have a capacity of 5,000 cfs and would serve both inflow and outflow requirements for the Colusa Reservoir Project.

An open-chute type spillway with an uncontrolled crest (ungated) and having a capacity of 2,500 cfs would discharge into Hunters Creek. Like Small and Large Sites Reservoirs, a small spillway is adequate because of the large water surface area in relation to the small, relatively dry tributary drainage area.

The outlet works facilities for Colusa Reservoir would include an outlet at Logan Dam and at Golden Gate Dam. The outlet works facility, located at Logan Dam, would contain the penstock for the Logan Pumping-Generating Plant and would be used to fill Colusa Reservoir and to make releases to Logan Forebay. The outlet facility located at Golden Gate Dam would only be used to help during an emergency evacuation. The DWR, Division of Safety and Dams requires that during an emergency evacuation, 10 percent of the maximum water depth must be released in 10 days. This equates to an estimated release capacity of 44,000 cfs, or 22,000 cfs at each outlet works facility. Alternative methods for evacuating the emergency release flows could include

the construction of an additional outlet works facility at Sites or Hunter Dam or an enlarged and gated spillway in either the Sites or Colusa compartment.

ISSUES COMMON TO ALL ALTERNATIVES

Land and Relocations

The Sites/Colusa Reservoir inundation area is very sparsely populated, with fewer than 100 residents living in the potential project area. However, the community of Sites would have to be relocated. Outside of the community of Sites, few utilities would have to be relocated, but the road to Stonyford would have to be relocated outside the reservoir.

Geology and Construction Materials

The availability of construction materials near the project site appears to be adequate for all alternative projects evaluated. A 1978 field investigation memorandum by DWR indicates that six impervious material alluvial fill areas totaling more than 50 million cubic yards lie along stream channels within the Sites/Colusa Reservoir area. Rockfill quantities of at least 185 million cubic yards are located along Logan Ridge or in the reservoir area. No sand and gravel deposits are located near the reservoir; the closest large source is north of Willows in an old channel of Stony Creek.

Probably the most significant technical factor affecting the construction of a Sites/Colusa Reservoir Project is seismicity. No seismic investigation has been conducted specifically for the Sites/Colusa Reservoir; however, an article in *The Journal of Geophysical Research* in 1988 reported on studies from 1969 to 1985 which discussed the seismicity of the area from Red Bluff to San Luis Reservoir.

The 1988 study implied the possibility of large-scale earthquake activity in the area emanating from "hidden" faults along the western Great Valley, other investigations have also examined the west side of the Sacramento Valley and identified several hot spots of micro-seismic activity related to "hidden" or "blind" faults. To date, the extent and potential of these hidden faults have yet to be adequately defined. This undefined potential for large-scale earthquake activity within the Sites/Colusa Reservoir Project region could substantially affect the design of the facilities and deserves considerable additional study.

COST ESTIMATE

The cost estimates for the facilities described in the previous sections are based on previous estimates performed by the Bureau of Reclamation. The previous estimates have been reviewed and adopted for the present cost estimate update. Several items in the previous cost estimates were modified to ensure that current design standards and safety factors were incorporated. Items not included in this estimate include environmental documentation, operation and maintenance costs, power costs, reservoir filling costs, and interest during construction.

SMALL AND LARGE SITES RESERVOIRS

The cost estimates for the Small and Large Sites Reservoir alternatives were determined by applying current unit costs to quantities found in the June 1964 Bureau of Reclamation report titled *West Sacramento Canal Unit, Reconnaissance Design Criteria and Cost Estimate Appendix* (Small Sites Report) and in the September 1980 Bureau of Reclamation report titled *West Sacramento Canal Unit, Appraisal Design Criteria and Cost Estimate Appendix* (Large Sites Report). Current unit costs were determined by escalating the unit costs found in the 1990 DWR report titled *Los Banos Grandes Facilities Report, Appendix A: Designs and Cost Estimates* (LBG Report). The costs were escalated to October 1996 dollars using the Bureau of Reclamation's Construction Cost Trends (CCT) indices. Tables 2a and 2b provide a detailed

breakdown of the estimated costs of constructing Small Sites and Large Sites Reservoirs. These tables also include an updated cost estimate for each cost item identified in the previous cost estimates, along with the quantities of the cost item or an indication that the estimated cost has been developed through a lump sum approach. The tables also include the Bureau of Reclamation CCT index for the month and year in which the estimated cost was developed and for October 1966. These Bureau of Reclamation cost indices are used to factor the previous cost estimate to October 1996 dollars. In some instances, only a unit cost has been provided, with no cost indices. In these cases, the unit cost has been taken from other sources. The far right-hand column of Tables 2a and 2b provides the cost reference for each cost item.

The Sites 1.2 maf alternative was revised to a 1.9 maf reservoir in the Large Sites Report. Because the cost estimates in the Large Sites Report are 16 years more current than the cost estimates found in the Small Sites Report, many of the unit costs from the Large Sites Report (escalated to October 1996 dollars) were used in place of the unit costs found in the Small Sites Report. For example, many of the dam construction unit costs found in the Large Sites Report (escalated to October 1996 dollars) were applied to the quantities found in the Small Sites Report. The outlet works cost estimate was factored as noted below under Outlet Works Capacity Adjustment to meet the criteria for emergency release drawdown.

Colusa Reservoir

The cost estimate for the Colusa Reservoir alternative was determined by incorporating the Large Sites Reservoir cost estimate information (developed from a prior report) and methodology for calculating the costs of Golden Gate Dam and Sites Dam. New cost estimates were developed for Hunters Dam, Logan Dam, Logan Forebay Dam, and nine saddle dams required for the Colusa Reservoir Project. The Large Sites Reservoir cost estimates were used as a basis for developing outlet works and spillway cost estimates for Colusa Reservoir. The cost estimates for

the outlet works were factored as described below in the Outlet Works Capacity Adjustment section. The cost estimate for the spillway was similarly adjusted.

For the new cost estimates, U.S. Geological Survey (USGS) 1:24,000 scale quad maps were used to locate Hunters Dam, Logan Dam, Logan Forebay Dam, and all nine saddle dams (new dams). Dam embankment quantities were calculated based on the typical Sites Dam cross section used in the 1980 Bureau of Reclamation report and the ground profile generated from the USGS maps. Using the detailed cost estimate for the Large Sites Golden Gate Dam as a basis for determining cost for the new dams, any new dam's cost was estimated by factoring the cost of the Golden Gate Dam by the ratio of the dam embanking volume of the new dam to the dam embankment volume of Golden Gate Dam.

The cost for Logan Canal was developed by applying linear foot unit costs to the 1.7 mile length of canal. The costs for linear foot of canal were developed for the Chico Landing CALFED conveyance component. Table 2c provides a detailed breakdown of the estimated costs of constructing Colusa Reservoir.

Right-of-Way Costs

Right-of-way cost of \$1,500 per acre was used for the Sites/Colusa Reservoir Project. Right-of-way costs were developed by the Bureau of Reclamation's Land Resources Branch (pers. comm. February 1997). The total project lands that need to be acquired include a buffer around the maximum water surface area. The ratio of total project land to maximum water surface area used in the cost estimate is 1.32 based on data from the LBG Report.

Outlet Works Capacity Adjustment

As described earlier in Facilities Descriptions, the outlet works facilities and/or the spillway must be able to evacuate 10 percent of the maximum water depth within ten days as required by DWR's Division of Safety of Dams. The spillway for the Sites/Colusa Reservoir Project was designed as an open-chute type with an uncontrolled crest (ungated) and therefore will not be able to contribute to the emergency release drawdown. Therefore, the emergency drawdown peak flow, estimated at 15,200 cfs for the Small Sites Reservoir, 22,000 cfs for the Large Sites Reservoir, and 44,000 cfs for the Colusa Reservoir, must be released through the outlet works or a redesigned gated spillway. For the Small Sites, Large Sites, and Colusa Reservoir alternatives, the earlier cost estimates for the outlet works assumed an outlet works capacity of 2,100 cfs. To develop a cost for the outlet works capable of releasing 15,200 cfs at Small Sites Reservoir, 22,000 cfs at Large Sites Reservoir, or 44,000 cfs (22,000 cfs at each additional facility) at Colusa Reservoir, the cost for the 2,100 cfs outlet works was factored by the following empirical equation:

$$\frac{(Cost)_1}{(Cost)_2} = \frac{Q_1^{3/4}}{Q_2^{3/4}}$$

Where Q is equal to capacity.

This cost factor formula is typically valid over moderate ranges in capacity; the validity over larger ranges is undetermined. However, because the estimated cost of the outlet works is a relatively low percentage of the total project cost, the impact of any error resulting from utilizing this ratio beyond its valid range is within the range of the accuracy of the estimate.

Pumping-Generating Plant Costs

The pumping-generating plant cost estimates are based on actual construction costs for the Waddell Pumping-Generating Plant in Arizona, which was completed in 1994 and is similar in size and scope to the Sites/Colusa Reservoir pumping-generating plants. To develop a cost for the Sites/Colusa Reservoir pumping-generating plants, the actual construction cost of the Waddell Pumping-Generating Plant (escalated to October 1996 dollars) was factored by the following empirical equation:

$$\frac{(Cost)_1}{(Cost)_2} = \frac{HP_1^{6/10}}{HP_2^{6/10}}$$

Where HP is equal to horsepower.

As with the cost factor formula used for estimating the new outlet works costs, this formula is also valid over moderate ranges in horsepower; the validity over larger ranges is undetermined. The impact of any error resulting from utilizing this ratio beyond its valid range is also expected to be within the range of the accuracy of the estimate.

Contingencies and Other Costs

All contingencies and engineering, construction management, and administrative factors were determined by historical engineering judgment based on similar level of cost estimation.

Contingencies were chosen to be 20 percent, and engineering, construction management, and administration were chosen to be 35 percent. A cost range was developed for either of the reservoir alternatives by subtracting 10 percent from the estimated capital cost for the low end cost and adding 15 percent to the estimated capital cost for the high end.

PRELIMINARY COST FINDINGS

Estimated costs of constructing Small Sites, Large Sites, and the Colusa Reservoir Projects and supporting facilities have been updated to an October 1996 basis as described above. Table 3 provides a summary of the estimated cost.

The total estimated capital cost of Small Sites Reservoir is \$566 million with a resulting calculated range of cost between \$509 and \$651 million. The total estimated capital cost for the Large Sites Reservoir is \$784 million with a calculated cost range of \$706 to \$902 million. The Colusa Reservoir Project has a total estimated construction cost of \$1,330 million and a calculated cost range of \$1,200 to \$1,530 million.

ENVIRONMENTAL CONSIDERATIONS

This portion of the report provides a summary of environmental considerations related to the proposed Sites/Colusa Reservoir Project. Wildlife, fish, plant, and cultural resources that could be affected by the proposed project have been identified and the extent of the possible impact on these resources described. For the most part, the information presented in this section was gathered from existing literature, with limited original research. No field work was conducted for this analysis.

WILDLIFE

The Colusa Reservoir Project could inundate 29,600 acres of terrestrial wildlife habitat and 25 miles of intermittent stream habitat. The Sites Reservoir alternative would inundate from 12,300 to 14,700 acres depending on the configuration. The most significant loss of wildlife habitat would be 700 acres of oak-woodland, which is considered breeding habitat for many species of reptiles, amphibians, birds, and mammals.

Fish, Amphibians, Reptiles, and Invertebrates

The small streams that run through the Sites/Colusa Reservoir Project area provide habitat for a number of fish species that are classified as nongame. Representative native species include Sacramento sucker, hitch, Sacramento squawfish, and Sacramento blackfish. The area may also support green sunfish, an introduced game fish. Salt Lake, located in Antelope Valley, has no fish, but supports abundant insect fauna.

General Wildlife

The proposed reservoir complex area supports a moderately diverse faunal assemblage. Mammals which may be found in the area include opossum, shrew, bats, black bear, raccoon, ring-tailed cat, weasel, badger, skunk, coyote, gray fox, squirrels, gophers, mice, rabbit, and black-tailed deer.

The deer population is average for the area and supports considerable hunting by landowners. The open grasslands and areas along the intermittent drainage provide limited yearling and winter deer use. Deer migration corridors are not expected to be impacted by the proposed reservoir, and impacts are projected to be minimal.

Numerous bird species can be found using the Antelope Valley portion of the proposed reservoir site, especially during spring and fall migrations. Salt Lake also provides habitat for numerous bird species, including curlews and sandpipers. Killdeer can be found nesting in open fields. Some of the common perching birds found nesting in the area include meadowlark, blackbird, jay, flycatcher, swallow, crow, starling, and mockingbird. Birds nesting in the oak woodlands include golden eagles, hawks, and owls. Game birds found in the area include quail, pheasant, dove, and pigeon.

Sensitive and Listed Fish and Wildlife Species

No State or federally listed fish species are known to exist within the Sites/Colusa Reservoir Project area.

Although no sensitive species of reptiles or amphibians have been recorded in the project area, it could be possible to find species such as the northern red-legged frog, foothill yellow-legged frog, western spadefoot, and western pond turtle. ~~All~~ these species are listed by the California Department of Fish and Game as "species of special concern."

The Valley elderberry longhorn beetle, a federally listed threatened species, has the potential to occur at the reservoir site. Limited numbers of elderberry plants occur sporadically along the areas intermittent streams. While this area is considered a transition zone between the federally listed valley subspecies and the non-listed coastal subspecies, it is possible that the valley subspecies could occur at this site.

Vernal pool habitats, if present, have the potential to support federally listed fairy and tadpole shrimp.

Several sensitive and State or federally listed bird species that have the potential to occur within the project area include golden eagle, burrowing owl, and tricolored blackbird. The Swainson's hawk, a State-listed threatened species, could use the open grassland or cropland habitats within the project area for nesting and foraging. It is also possible that the area may receive sporadic use by wintering bald eagles.

Wintering greater sandhill cranes, State-listed threatened, is a common winter migrant to the eastern Sacramento Valley. While the crane does not nest in the project area, it could use the open grasslands for foraging.

The San Joaquin pocket mouse, a species of special concern, is known to occur within or adjacent to the project area.

VEGETATION

Vegetation at the Sites/Colusa Reservoir Project consists primarily of grasslands (23,065 acres) comprised of wild oat, brome grass, and fescues. About 10 percent of the land is planted in barley (1,300 acres of agriculture). Some valley needlegrass grassland communities may be found in the area. The woodlands (1,345 acres) are comprised mostly of blue oaks and can be found throughout the area, particularly in the western upland areas. Riparian vegetation (220 acres) occurs along Antelope, Stone Corral, Funks, and Grapevine Creeks; however, these areas have been severely degraded as a result of overgrazing and extensive cultivation to the stream edges. The majority of the riparian vegetation found in this area consists of sycamore, willow, and cottonwood. Aquatic plant species found in the drainage areas include bulrush, cattail, rush, and smartweed. Approximately 120 acres of disturbed area exists within the reservoir area.

Sensitive and Listed Plant Species

To date, no listed plant species have been recorded in the proposed Sites/Colusa Reservoir Project area.

Candidate species for federal listing that may occur in the project area include tropidocarpum, San Joaquin saltbush, diamond-petaled California poppy, and adobe lily. In the case of the adobe lily, large amounts of potential habitat for this plant exists throughout the project site, particularly north of the community of Sites.

Two plants, brittlescale and dimorphic snapdragon, considered by the California Native Plant Society to be either rare, threatened, or endangered in California and elsewhere, may occur within the Sites/Colusa Reservoir Project area.

Because of the presence of a large alkaline and vernal wetland at the northern end of the project site, Salt Lake, a number of other sensitive plant species, such as Ferris' milkvetch, heartscale, Hoover's spurge, palmate bird's-beak, Heckard's peppergrass, slender orcutt grass, Greene's tuctoria, and Colusa grass, may be found in the project area. Several of these species are either listed or candidates for listing.

WETLANDS

The percentage of wetland acreage within the proposed reservoir site is relatively small. A seven-acre saline vernal lake, Salt Lake, occurs within the area. Vernal pools, which are distinct from the vernal lake, are uncommon in the area.

The proposed reservoir complex would inundate portions of seven intermittent streams. Approximately four miles of Grapevine Creek, eight miles of Funks Creek, six miles of Antelope Creek, and three miles of Stone Corral Creek would be eliminated in the Sites portion of the reservoir complex. In addition, portions of Hunters, Logan, and Willow Creeks would be eliminated with the Colusa Reservoir area.

Within the Colusa Reservoir area, there are approximately 36 miles of intermittent creek, four miles of shrub-scrub wetland, one mile of forested wetland, 17 miles of temporarily flooded wetland, three miles of saturated wetland, nine miles of seasonally flooded wetland, and 39 acres of ponds.

CULTURAL RESOURCES

A recent search of the Historic Resources Information System located at Rohnert Park, California, revealed one listing that indicated homesteading and ranching took place in the project area during the historic period. Other sources indicate that there are 18 prehistoric sites and 13 historic sites in the area. Of these 31 sites, five are significant, and at least two others have the potential to be significant, but require additional study. The project site also contains three significant ethnographic sites.

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Table 1
SUMMARY OF PHYSICAL CHARACTERISTICS
SITES/COLUSA RESERVOIR PROJECT

	Small Sites	Large Sites	Colusa
Storage			
Gross (acre-feet)	1,200,000	1,900,000	3,000,000
Maximum Water Surface Area (acres)	12,300	14,700	28,500
Reservoir Water Surface Elevations			
Maximum Operating (feet MSL)	480	532	520
Minimum Operating (feet MSL)	320	320	530
Dam Crest Elevation (feet MSL)	490	541	529
Dam Height			
Sites (feet)	243	294	280
Golden Gate (feet)	251	302	290
Hunters (feet)	---	---	270
Logan (feet)	---	---	260
Saddle Dams			
Number	5	12	11
Height Range (feet)	10 to 80	27 to 112	35 to 140
Pumping-Generating Plants			
Static Lift from Tehama-Colusa Canal			
Maximum (feet)	280	332	310
Minimum (feet)	155	115	110
Capacity			
Maximum (cfs)	5,000	5,000	5,000
Spillway Capacity (cfs)	250	250	2,500
Outlet Works Capacity (cfs)	15,200	22,000	40,400
Logan Creek Capacity (cfs)	---	---	5,000
Logan Canal Length (mile)	---	---	1.7

Table 2a
ESTIMATED COSTS
SMALL SITES RESERVOIR (1.2 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT ^a	USBR INDEX OCT. 63	USBR INDEX OCT. 96	UNIT COST OCT. 63	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
SITES RESERVOIR, DAMS, AND DIKES								
I. RIGHTS-OF-WAY								
Reservoir (Includes Buffer Area Factor of 1.32)	16,240	AC				\$1,500	\$24,360,000	5
Sites - Cottonwood Elverta #2 Loop	JOB	LS				\$13,276	\$13,276	1, sheet 27
SUBTOTAL RIGHTS-OF-WAY							\$24,373,276	
II. RELOCATION OF EXISTING PROPERTY								
Secondary Road Relocation	JOB	LS				\$13,254,000	\$13,254,000	1, sheet 3
12 kV Electrical Line	JOB	LS				\$438,000	\$438,000	1, sheet 3
SUBTOTAL RELOCATION OF EXISTING PROPERTY							\$13,692,000	
III. CLEARING RESERVOIR								
Reservoir clearing	700	AC				\$1,097	\$768,033	3, item IV-a
SUBTOTAL CLEARING LANDS							\$768,033	
IV. ACCESS ROADS								
Access Roads	JOB	LS				\$2,539,000	\$2,539,000	4
SUBTOTAL ACCESS ROADS							\$2,539,000	
V. GOLDEN GATE DAM, SITES DAM, AND 5 DIKES								
Diversion and care of river and unwatering foundation	JOB	LS	43	207	\$50,000	\$240,698	\$240,698	2, sheet 3
Excavation all classes, equalizing channel	183,000	CY				\$3.58	\$655,140	1, sheet 4
Excavation all classes, for foundations	419,500	CY				\$3.23	\$1,354,985	3, item I-d
Excavation, rock for grout cap	2,000	CY				\$7.15	\$14,300	1, sheet 3
Excavation, stripping, borrow pits	340,000	CY				\$1.15	\$391,000	3, item I-c
Excavation, common, in borrow area and transportation to dam embankment	5,320,000	CY				\$3.22	\$17,130,400	3, item I-c
Excavation, rock and rockfines in borrow area and transportation to embankments	1,484,000	CY				\$7.15	\$10,610,600	1, sheet 3
Placing earthfill in embankment	4,859,900	CY				\$0.95	\$4,616,905	3, item I-f
Placing rock and rockfines in embankment	2,024,000	CY				\$0.75	\$1,518,000	3, item I-h
Furnish and place sand and gravel filter	27,100	CY				\$8.54	\$231,434	3, items I-i, I-j
Furnish and place riprap	54,000	CY				\$31.64	\$1,708,560	3, item I-n
Furnish and place bedding for riprap	28,000	CY				\$11.79	\$330,120	3, item I-m
Furnish 8-inch diameter sewer pipe and constructing toe drains	2,350	LF	49	196	\$5.00	\$20.00	\$47,000	2, sheet 3
Gravel surfacing on dam crest	1,850	TON				\$11.99	\$22,182	1, sheet 4 avg
Seeding	43,340	SY	42	176	\$0.03	\$0.13	\$5,448	2, sheet 4

Table 2a
ESTIMATED COSTS
SMALL SITES RESERVOIR (1.2 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT ^a	USBR INDEX OCT. 63	USBR INDEX OCT. 96	UNIT COST OCT. 63	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Water for seeding	1,000	MGAL	42	176	\$2.50	\$10.48	\$10,476	2, sheet 4
Drilling grout holes 0 to 30 feet	18,180	LF				\$18.70	\$339,966	3, item I-q
Drilling grout holes 30 to 60 feet	9,090	LF				\$18.70	\$169,983	3, item I-q
Drilling grout holes 60 to 110 feet	5,760	LF				\$18.70	\$107,712	3, item I-q
Drilling grout holes 110 to 160 feet	1,720	LF				\$18.70	\$32,164	3, item I-q
Concrete in grout caps	2,000	CY	42	176	\$35.00	\$146.67	\$293,333	2, sheet 4
Furnish and install grout pipe and fittings	17,400	LB	42	176	\$0.95	\$3.98	\$69,269	2, sheet 4
Hookups to grout holes	610	EA	42	176	\$10.00	\$41.90	\$25,562	2, sheet 4
Pressure grouting	52,130	SKS	42	176	\$2.50	\$10.48	\$546,124	2, sheet 4
Cement	16,090	BBL	42	176	\$5.00	\$20.95	\$337,124	2, sheet 4
SUBTOTAL DAMS							\$40,808,484	
VI SPILLWAY								
Excavation, open cut, all classes	8,557	CY				\$4.03	\$34,485	3, avg items II-a, III-a
Backfill	1,200	CY				\$8.17	\$9,804	3, item III-f
Special compacted backfill	300	CY				\$13.51	\$4,053	1, sheet 5
Structural Concrete in floors and crest	485	CY				\$365.24	\$177,141	3, avg items II-h, III-c, III-d
Structural Concrete in walls	479	CY				\$365.24	\$174,950	3, avg items II-h, III-c, III-d
Drilling and grouting anchors	2,260	LF				\$16.86	\$38,104	1, sheet 5
F&I 4" dia. S.P. drains	180	LF				\$16.86	\$3,035	1, sheet 5
Riprap	200	CY				\$31.64	\$6,328	3, item I-n
Bedding for riprap	100	CY				\$11.79	\$1,179	3, item I-n
F&I 6" dia. S.P. drains	700	LF				\$16.86	\$11,802	1, sheet 5
10% Minor items	JOB	LS					\$46,088	
Subtotal Spillway (1.9 MAF ALT)							\$506,969	
Factor cost by ratio of max. water depths (244.3/295.8)=	0.826							
SUBTOTAL SPILLWAY (1.2 MAF)							\$418,736	
VII OUTLET WORKS								
Excavation all classes tailrace	36,000	CY				\$7.40	\$266,400	1, sheet 6
Excavation, open cut	6,000	CY				\$3.38	\$20,280	3, item II-a
Excavation, tunnel	9,700	CY				\$128.27	\$1,244,219	3, item VI-s
Excavation, gate chamber and shaft	6,300	CY				\$146.59	\$923,517	3, item II-c
Drilling grout holes	13,400	LF				\$18.70	\$250,580	3, item I-q
F&I grout pipe and fittings	6,700	LB				\$4.59	\$30,753	1, sheet 6
Hookups to grout holes	446	EA				\$91.73	\$40,912	1, sheet 6
Pressure grouting	13,400	SKS				\$91.73	\$1,229,182	1, sheet 6
Concrete in tunnel lining	7,240	CY				\$320.68	\$2,321,723	3, item VI-t
Structural Concrete in intake	3,950	CY				\$339.50	\$1,341,025	3, item VI-k
Structural Concrete in gate chamber and shaft	3,110	CY				\$339.50	\$1,055,845	3, item VI-k

Table 2a
ESTIMATED COSTS
SMALL SITES RESERVOIR (1.2 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT ^a	USBR INDEX OCT. 63	USBR INDEX OCT. 96	UNIT COST OCT. 63	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Structural Concrete in stilling basin	3,850	CY				\$339.50	\$1,307,075	3, item VI-k
Structural Concrete in anchor blocks	3,000	CY				\$256.15	\$768,450	3, item VII-d
Metal control house	JOB	LS				\$9,173	\$9,173	1, sheet 6
Specially compacted backfill	800	CY				\$15.61	\$12,488	1, sheet 6
F&I 11x11 fixed wheel gates	116,000	LB				\$5.55	\$643,800	1, sheet 6
2-42" H.J. valves and controls	32,222	LB				\$6.28	\$202,354	1, sheet 6
2 guard gates for 42" H.J. valves	32,000	LB				\$6.92	\$221,440	1, sheet 6
4-6.5'x8.0' H.P. gates	564,000	LB				\$4.59	\$2,588,760	1, sheet 6
144" dia. penstock & manifold for H.P. gates	2,000,000	LB				\$1.65	\$3,300,000	3, item VII-c
F&I tunnel supports	288,000	LB				\$3.66	\$1,054,080	3, item II-e
Trashrack metalwork	74,000	LB				\$3.63	\$268,620	3, item VI-q
F&I tower bulkhead	100,000	LB				\$3.02	\$302,000	3, item VI-n
Tunnel vent system	JOB	LS				\$129,555	\$129,555	1, sheet 6
Other misc. metalwork	3,000	LB				\$3.63	\$10,890	3, item VI-ii
Rockbolts	27,900	LF				\$64.14	\$1,789,506	3, item VI-g
Chain link fabric	23,000	SF				\$12.88	\$296,240	1, sheet 6
10% Minor items	JOB	LS					\$2,162,887	
SUBTOTAL OUTLET WORKS							\$23,791,754	
Upsize Outlet Works for Emergency Evacuation								
Increase Outlet Works Capacity from 2,100cfs to 15,200cfs								
Cost Factor = $(15,200/2,100)^{3/8} = 2.10$	2.10						\$49,962,683	
VIII. SITES PUMPING - GENERATING PLANT (Located at Golden Gate Dam)								
(Q=5,000cfs, TDH=290, eff=75%, 219,350 HP)								
Structure, Equipment and Electrical, Complete	JOB	LS					\$212,330,000	4
SUBTOTAL SITES PUMPING - GENERATING PLANT							\$212,330,000	
IX. SITES PUMPING/GENERATING PLANT SWITCHYARD								
Station Equipment, Electrical								
Transformer, 3 Phase, 65 MVA, 230/6.9 kv	1	EA				\$1,028,350	\$1,028,350	1, sheet 26
230-kv Line Bay, 10,000 MVA	3	EA				\$650,325	\$1,950,975	1, sheet 26
230-kv Bus-Tie Bay, 10,000 MVA	1	EA				\$573,089	\$573,089	1, sheet 26
Coupling Capacitor, (w/potential device)	5	EA				\$12,049	\$60,245	1, sheet 26
Carrier equipment	2	EA				\$30,894	\$61,788	1, sheet 26
Telemetry and supervisory control	JOB	LS				\$183,722	\$183,722	1, sheet 26
SUBTOTAL SWITCHYARD							\$3,858,169	
Increase capacity from 2,100cfs to 5,000cfs								
Cost Factor = $(5,000/2,100)^{6/10} = 1.683$	1.683							
OUTLET WORKS COST							\$5,493,298	

Table 2a
ESTIMATED COSTS
SMALL SITES RESERVOIR (1.2 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT ^a	USBR INDEX OCT. 63	USBR INDEX OCT. 96	UNIT COST OCT. 63	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
X. SITES-COTTONWOOD ELVERTA #2 LOOP								
Clearing Land	JOB	LS				\$3,841	\$3,841	1, sheet 27
Towers and Fixtures	JOB	LS				\$405,911	\$405,911	1, sheet 27
Conductors and Devices	JOB	LS				\$215,416	\$215,416	1, sheet 27
SUBTOTAL #2 LOOP							\$623,168	
SUBTOTAL							\$349,000,000	
CONTINGENCIES @ 20%							\$69,800,000	
ESTIMATED CONSTRUCTION COST							\$419,000,000	
ENGR, LEGAL, AND ADMIN @ 35%							\$147,000,000	
ESTIMATED CAPITAL COST							\$566,000,000	
ESTIMATED CAPITAL COST RANGE								
LOW (-10%)							\$509,000,000	
HIGH (+15%)							\$651,000,000	
COST ESTIMATE DOES NOT INCLUDE ENLARGING FUNKS RESERVOIR.								

Footnote:

^aAC=acre; LS=lump sum; MI=mile; CY=cubic yard; LF=linear foot; SY=square yard; MGAL=million gallons; LB=pound; EA=each; BBL=barrel

Cost References:

1. U.S. Bureau of Reclamation, *Appraisal Design Criteria and Cost Estimate Appendix, West Sacramento Canal Unit, Sacramento River Division, CVP*, September 1980.
2. U.S. Bureau of Reclamation, *Reconnaissance Design Criteria and Cost Estimate Appendix, West Sacramento Canal Unit, Sacramento River Division, CVP*, June 1964.
3. California Department of Water Resources, *Los Banos Grandes Facilities Report, Appendix A: Designs and Cost Estimates*, December 1990.
4. Cost developed by Bookman-Edmonston Engineering.
5. U.S. Bureau of Reclamation, Land Resources Branch, Graham McMullen, February 1997.

Table 2b
ESTIMATED COSTS
LARGE SITES RESERVOIR (1.9 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT*	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
SITES RESERVOIR, DAMS, AND DIKES								
I. RIGHTS-OF-WAY								
Sites-Cottonwood Elverta #2 Loop	JOB	LS	127	217	\$7,770	\$13,276	\$13,276	1, sheet 27
Reservoir (Includes Buffer Area Factor of 1.32)	19,400	AC				\$1,500	\$29,100,000	4
SUBTOTAL RIGHTS-OF-WAY							\$29,113,276	
II. RELOCATION OF EXISTING PROPERTY								
Secondary Road Relocation	14	MI	137	237	\$653,850	\$1,131,113	\$15,835,579	1, sheet 3
12 kV Electrical Line	JOB	LS	129	234	\$288,460	\$523,253	\$523,253	1, sheet 3
SUBTOTAL RELOCATION OF EXISTING PROPERTY							\$16,358,832	
III. CLEARING RESERVOIR								
Reservoir clearing	700	AC				\$1,097	\$768,033	2, item IV-a
SUBTOTAL CLEARING RESERVOIR							\$768,033	
IV. ACCESS ROADS								
Access roads	5.7	MI	137	237	\$307,690	\$532,281	\$3,034,003	1, sheet 3
SUBTOTAL ACCESS ROADS							\$3,034,003	
V. GOLDEN GATE DAM - Earth and Rockfill Structure; Crest Elevation 541.3								
Excavation, all classes for foundation	468,000	CY				\$3.23	\$1,511,640	2, item I-d
Stripping borrow pits	319,000	CY				\$1.15	\$366,850	2, item I-c
Excavation, impervious and hauling to dam (borrow)	3,185,000	CY				\$3.22	\$10,255,700	2, item I-e
Excavation, rockfines and hauling to dam (borrow)	1,227,500	CY	123	176	\$5.00	\$7.15	\$8,782,114	1, sheet 3
Excavation, rock and hauling to dam (borrow)	2,799,000	CY	123	176	\$5.00	\$7.15	\$20,025,366	1, sheet 3
Placing impervious	2,722,000	CY				\$0.95	\$2,585,900	2, item I-f
Placing rockfines	1,534,400	CY				\$0.75	\$1,150,800	2, item I-h
Placing rock	3,998,800	CY				\$0.75	\$2,999,100	2, item I-h
F&P sand filter and gravel drain	145,300	CY				\$8.54	\$1,240,862	2, items I-i & I-j
Grouting foundation	JOB	LS	123	176	\$418,000	\$598,114	\$598,114	1, sheet 4
Drains	2,790	LF	123	176	\$7.75	\$11.09	\$30,940	1, sheet 4
Gravel on crest	2,066	CY	123	176	\$7.75	\$11.09	\$22,911	1, sheet 4
10% minor items	JOB	LS					\$4,957,030	
SUBTOTAL GOLDEN GATE DAM							\$54,527,325	

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Table 2b
ESTIMATED COSTS
LARGE SITES RESERVOIR (1.9 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT*	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
VI. SITES DAM - Earthfill and Rockfill Structure; Crest Elevation 541.5								
Diversion and care of river	JOB	LS	125	207	\$144,000	\$238,464	\$238,464	1, sheet 4
Excavation for equalizing channel and fill in coffer dams	183,000	CY	123	176	\$2.50	\$3.58	\$654,634	1, sheet 4
Excavation, all classes for foundation	209,300	CY				\$3.23	\$676,039	2, item I-d
Stripping borrow pits	167,000	CY				\$1.15	\$192,050	2, item I-c
Excavation, impervious and hauling to dam (borrow)	1,666,000	CY				\$3.22	\$5,364,520	2, item I-e
Excavation, rockfines and hauling to dam (borrow)	470,100	CY	123	176	\$5.00	\$7.15	\$3,363,317	1, sheet 4
Excavation, rock and hauling to dam (borrow)	1,133,600	CY	123	176	\$5.00	\$7.15	\$8,110,309	1, sheet 4
Placing impervious	1,424,000	CY				\$0.95	\$1,352,800	2, item I-f
Placing rockfines	587,600	CY				\$0.75	\$440,700	2, item I-h
Placing rock	1,619,400	CY				\$0.75	\$1,214,550	2, item I-h
F&P sand filters and gravel drains	128,600	CY				\$8.54	\$1,098,244	1, items I-i & I-j
Grouting foundation	JOB	LS	123	176	\$166,000	\$237,528	\$237,528	1, sheet 4
Drains	2,350	LF	123	176	\$12.75	\$18.24	\$42,873	1, sheet 4
Gravel on crest	730	CY	123	176	\$9.00	\$12.88	\$9,401	1, sheet 4
10% Minor items	JOB	LS					\$2,299,543	1, sheet 4
SUBTOTAL SITES DAM							\$25,294,973	
VII. DIKES								
Excavation, all classes for foundation	539,000	CY				\$3.23	\$1,740,970	2, item I-d
Excavation, impervious and hauling to dam (borrow)	4,115,500	CY				\$3.22	\$13,251,910	2, item I-e
Excavation, sand, gravel and hauling to dam (borrow)	970,000	CY	123	176	\$6.65	\$9.52	\$9,229,984	1, sheet 5
Excavation, rock and hauling to dam (borrow)	1,671,000	CY	123	176	\$6.65	\$9.52	\$15,900,312	1, sheet 5
Placing impervious	3,517,500	CY				\$0.95	\$3,341,625	2, item I-f
Placing rockfines	1,212,500	CY				\$0.75	\$909,375	2, item I-h
Placing rock	2,387,500	CY				\$0.75	\$1,790,625	2, item I-h
F&P riprap	169,700	CY				\$31.64	\$5,369,308	2, item I-n
F&P filter blanket	504,100	CY				\$8.54	\$4,305,014	2, item I-i
F&P bedding for riprap	84,900	CY				\$11.79	\$1,000,971	2, item I-m
Grouting foundation	JOB	LS	123	176	\$568,000	\$812,748	\$812,748	1, sheet 5
10% Minor items	JOB	LS					\$5,765,284	
SUBTOTAL DIKES							\$57,652,842	
VIII. SPILLWAY								
Excavation, open cut, all classes	8,557	CY				\$4.03	\$34,485	2, avg items II-a, III-a

Table 2b
ESTIMATED COSTS
LARGE SITES RESERVOIR (1.9 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT*	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Backfill	1,200	CY				\$8.17	\$9,804	2, item III-f
Special compacted backfill	300	CY	128	186	\$9.30	\$13.51	\$4,054	1, sheet 5
Structural Concrete in floors and crest	485	CY				\$365.24	\$177,141	2, avg items II-h, III-c, III-d
Structural Concrete in walls	479	CY				\$365.24	\$174,950	2, avg items II-h, III-c, III-d
Drilling and grouting anchors	2,260	LF	128	186	\$11.60	\$16.86	\$38,095	1, sheet 5
F&I 4" dia. S.P. drains	180	LF	128	186	\$11.60	\$16.86	\$3,034	1, sheet 5
Riprap	200	CY				\$31.64	\$6,328	2, item I-n
Bedding for riprap	100	CY				\$11.79	\$1,179	2, item I-m
F&I 6" dia. S.P. drains	700	LF	128	186	\$11.60	\$16.86	\$11,799	1, sheet 5
10% Minor items	JOB	LS					\$46,087	
SUBTOTAL SPILLWAY							\$306,957	
IX. OUTLET WORKS								
Excavation all classes tailrace	36,000	CY	128	206	\$4.60	\$7.40	\$266,513	1, sheet 6
Excavation, open cut	6,000	CY				\$3.38	\$20,280	2, item II-a
Excavation, tunnel	9,700	CY				\$128.27	\$1,244,219	2, item VI-s
Excavation, gate chamber and shaft	6,300	CY				\$146.59	\$923,517	2, item II-c
Drilling grout holes	13,400	LF				\$18.70	\$250,580	2, item I-q
F&I grout pipe and fittings	6,700	LB	128	206	\$2.85	\$4.59	\$30,731	1, sheet 6
Hookups to grout holes	446	EA	128	206	\$57.00	\$91.73	\$40,914	1, sheet 6
Pressure grouting	13,400	Sack	128	206	\$57.00	\$91.73	\$1,229,241	1, sheet 6
Concrete in tunnel lining	7,240	CY				\$320.68	\$2,321,723	2, item VI-t
Structural Concrete in intake	3,950	CY				\$339.50	\$1,341,025	2, item VI-k
Structural Concrete in gate chamber and shaft	3,110	CY				\$339.50	\$1,055,845	2, item VI-k
Structural Concrete in stilling basin	3,850	CY				\$339.50	\$1,307,075	2, item VI-k
Structural Concrete in anchor blocks	3,000	CY				\$256.15	\$768,450	2, item VII-d
Metal control house	JOB	LS	128	206	\$5,700	\$9,173	\$9,173	1, sheet 6
Specially compacted backfill	800	CY	128	206	\$9.70	\$15.61	\$12,489	1, sheet 6
F&I 11x11 fixed wheel gates	116,000	LB	128	206	\$3.45	\$5.55	\$644,072	1, sheet 6
2-42" H.J. valves and controls	32,222	LB	128	206	\$3.90	\$6.28	\$202,243	1, sheet 6
2 guard gates for 42" H.J. valves	32,000	LB	128	206	\$4.30	\$6.92	\$221,450	1, sheet 6
4-6.5'x8.0' H.P. gates	564,000	LB	128	206	\$2.85	\$4.59	\$2,586,909	1, sheet 6
144" dia. penstock & manifold for H.P. gates	2,000,000	LB				\$1.65	\$3,300,000	2, item VII-c
F&I tunnel supports	288,000	LB				\$3.66	\$1,054,080	2, item II-e
Trashrack metalwork	74,000	LB				\$3.63	\$268,620	2, item VI-q
F&I tower bulkhead	100,000	LB				\$3.02	\$302,000	2, item VI-n

Table 2b
ESTIMATED COSTS
LARGE SITES RESERVOIR (1.9 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT*	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Tunnel vent system	JOB	LS	128	206	\$80,500	\$129,555	\$129,555	1, sheet 6
Other misc. metalwork	3,000	LB				\$3.63	\$10,890	2, item VI-ii
Rockbolts	27,900	LF				\$64.14	\$1,789,506	2, item VI-y
Chain link fabric	23,000	SF	128	206	\$8.00	\$12.88	\$296,125	1, sheet 6
10% Minor items	JOB	LS					\$2,162,722	
SUBTOTAL OUTLET WORKS							\$23,789,947	
Upsize Outlet Works for Emergency Evacuation								
Increase Outlet Works capacity from 2,100cfs to 22,000cfs								
Cost Factor = $(22,000/2100)^{3/8} = 2.413$	2.413							
OUTLET WORKS COST							\$57,405,142	
X. SITES PUMPING - GENERATING PLANT (Located at Golden Gate Dam)								
(Q=5,000cfs, TDH=342, eff=75%, 258,680 HP)								
Structures, Equipment and Electrical, Complete	JOB	LS					\$234,750,000	3
SUBTOTAL SITES PUMPING - GENERATING PLANT							\$234,750,000	
XI. SITES PUMPING-GENERATING PLANT SWITCHYARD								
Station Equipment, Electrical								
Transformer, 3 Phase, 65 MVA, 230/6.9 kv	1	EA	123	190	\$665,721	\$1,028,350	\$1,028,350	1, sheet 26
230-kv Line Bay, 10,000 MVA	3	EA	123	190	\$421,000	\$650,325	\$1,950,976	1, sheet 26
230-kv Bus-Tie Bay, 10,000 MVA	1	EA	123	190	\$371,000	\$573,089	\$573,089	1, sheet 26
Coupling Capacitor, (w/potential device)	5	EA	123	190	\$7,800	\$12,049	\$60,244	1, sheet 26
Carrier equipment	2	EA	123	190	\$20,000	\$30,894	\$61,789	1, sheet 26
Telemetry and supervisory control	JOB	LS	123	190	\$118,936	\$183,722	\$183,722	1, sheet 26
SUBTOTAL SWITCHYARD							\$3,858,169	
Increase capacity from 2,100cfs to 5,000cfs								
Cost Factor = $(5,000/2100)^{6/10} = 1.683$	1.683							
OUTLET WORKS COST							\$6,493,299	
XII. SITES-COTTONWOOD ELVERTA #2 LOOP								
Clearing Land	JOB	LS	126	217	\$2,230	\$3,841	\$3,841	1, sheet 27
Towers and Fixtures	JOB	LS	126	217	\$235,690	\$405,911	\$405,911	1, sheet 27
Conductors and Devices	JOB	LS	126	217	\$125,080	\$215,416	\$215,416	1, sheet 27
SUBTOTAL #2 LOOP							\$625,167	

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Table 2b
ESTIMATED COSTS
LARGE SITES RESERVOIR (1.9 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT*	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
SUBTOTAL							\$484,000,000	
CONTINGENCIES @ 20%							\$96,800,000	
ESTIMATED CONSTRUCTION COST							\$581,000,000	
ENGR, LEGAL, AND ADMIN @ 35%							\$203,000,000	
ESTIMATED CAPITAL COST							\$784,000,000	
ESTIMATED CAPITAL COST RANGE								
LOW (-10%)							\$706,000,000	
HIGH (+15%)							\$902,000,000	
COST ESTIMATE DOES NOT INCLUDE FUNKS DAM ENLARGEMENT.								

Footnote:

*LS=lump sum; AC=acre; MI=mile; CY=cubic yard; LF=linear foot; LB=pound; SF=square foot; EA=each

Cost References:

1. U.S. Bureau of Reclamation, *Appraisal Design Criteria and Cost Estimate Appendix, West Sacramento Canal Unit, Sacramento River Division, CVP*, September 1980.
2. California Department of Water Resources, *Los Banos Grandes Facilities Report, Appendix A: Designs and Cost Estimates*, December 1990.
3. Cost developed by Bookman-Edmonston Engineering.
4. U.S. Bureau of Reclamation, Land Resources Branch, Graham McMullen, February 1997.

Table 2c
ESTIMATED COSTS
COLUSA RESERVOIR (3.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
I. RIGHTS-OF-WAY								
Colusa Reservoir (Includes Buffer Area Factor of 1.32)	39,072	AC				\$1,500	\$58,608,000	1
Logan Canal (1.7 Miles by 350 Feet Wide)	72	AC				\$1,500	\$108,000	1
Logan Forebay (Includes Buffer Area Factor of 1.32)	68	AC				\$1,500	\$102,000	1
SUBTOTAL RIGHTS-OF-WAY							\$58,818,000	
II. RELOCATION OF EXISTING PROPERTY								
Secondary Road Relocation	JOB	LS				\$31,672,000	\$31,672,000	2
12 kV Electrical Line	JOB	LS				\$1,046,000	\$1,046,000	2
SUBTOTAL RELOCATION OF EXISTING PROPERTY							\$32,718,000	
III. CLEARING RESERVOIR								
Reservoir clearing	1,345	AC				\$1,097	\$1,475,721	3, item IV-a
SUBTOTAL CLEARING RESERVOIR							\$1,475,721	
IV. ACCESS ROADS								
Access roads	JOB	LS				\$6,068,000	\$6,068,000	2
SUBTOTAL ACCESS ROADS							\$6,068,000	
V. GOLDEN GATE DAM - Earth and Rockfill Structure; Crest Elevation 541.3								
Total Embankment Volume	8,255,200	CY						
Excavation, all classes for foundation	468,000	CY				\$3.23	\$1,511,640	3, item Id
Stripping borrow pits	319,000	CY				\$1.15	\$366,850	3, item Ic
Excavation, impervious and hauling to dam (borrow)	3,185,000	CY				\$3.22	\$10,255,700	3, item Ie
Excavation, rockfines and hauling to dam (borrow)	1,227,500	CY	123	176	\$5.00	\$7.15	\$8,782,114	4, sheet 3
Excavation, rock and hauling to dam (borrow)	2,799,000	CY	123	176	\$5.00	\$7.15	\$20,025,366	4, sheet 3
Placing impervious	2,722,000	CY				\$0.95	\$2,585,900	3, item If
Placing rockfines	1,534,400	CY				\$0.75	\$1,150,800	3, item Ih
Placing rock	3,998,800	CY				\$0.75	\$2,999,100	3, item Ih
F&P sand filter and gravel drain	145,300	CY				\$8.54	\$1,240,862	3, items Ii & Ij
Grouting foundation	JOB	LS	123	176	\$418,000	\$598,114	\$598,114	4, sheet 4
Drains	2,790	LF	123	176	\$7.75	\$11.09	\$30,940	4, sheet 4
Gravel on crest	2,066	CY	123	176	\$7.75	\$11.09	\$22,911	4, sheet 4
10% minor items	JOB	LS					\$4,957,030	
SUBTOTAL GOLDEN GATE DAM							\$34,527,323	

Table 2c
ESTIMATED COSTS
COLUSA RESERVOIR (3.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
VI. SITES DAM - Earthfill and Rockfill Structure; Crest Elevation 541.3								
Total Embankment Volume	3,631,000	CY						
Diversion and care of river	JOB	LS	125	207	\$144,000	\$238,464	\$238,464	4, sheet 4
Excavation for equalizing channel and fill in coffer dams	183,000	CY	123	176	\$2.50	\$3.58	\$654,634	4, sheet 4
Excavation, all classes for foundation	209,300	CY				\$3.23	\$676,039	3, item Id
Stripping borrow pits	167,000	CY				\$1.15	\$192,050	3, item Ic
Excavation, impervious and hauling to dam (borrow)	1,666,000	CY				\$3.22	\$5,364,520	3, item Ic
Excavation, rockfines and hauling to dam (borrow)	470,100	CY	123	176	\$5.00	\$7.15	\$3,363,317	4, sheet 4
Excavation, rock and hauling to dam (borrow)	1,133,600	CY	123	176	\$5.00	\$7.15	\$8,110,309	4, sheet 4
Placing impervious	1,424,000	CY				\$0.95	\$1,352,800	3, item If
Placing rockfines	587,600	CY				\$0.75	\$440,700	3, item Ih
Placing rock	1,619,400	CY				\$0.75	\$1,214,550	3, item Ih
F&P sand filters and gravel drains	128,600	CY				\$8.54	\$1,098,244	3, items Ii & Ij
Grouting foundation	JOB	LS	123	176	\$166,000	\$237,528	\$237,528	4, sheet 4
Drains	2,350	LF	123	176	\$12.75	\$18.24	\$42,873	4, sheet 4
Gravel on crest	730	CY	123	176	\$9.00	\$12.88	\$9,401	4, sheet 4
10% Minor items	JOB	LS					\$2,299,543	4, sheet 4
SUBTOTAL SITES DAM							\$25,294,973	
VII. HUNTERS DAM - Earthfill and Rockfill Structure; Crest Elevation 541.3								
Total Embankment Volume	7,521,700	CY						
Excavation, all classes for foundation	426,417	CY				\$3.23	\$1,377,326	3, item Id
Stripping borrow pits	290,656	CY				\$1.15	\$334,254	3, item Ic
Excavation, impervious and hauling to dam (borrow)	2,902,003	CY				\$3.22	\$9,344,449	3, item Ic
Excavation, rockfines and hauling to dam (borrow)	1,118,433	CY	123	176	\$5.00	\$7.15	\$8,001,796	4, sheet 3
Excavation, rock and hauling to dam (borrow)	2,550,300	CY	123	176	\$5.00	\$7.15	\$18,246,050	4, sheet 3
Placing impervious	2,480,142	CY				\$0.95	\$2,356,135	3, item If
Placing rockfines	1,398,064	CY				\$0.75	\$1,048,548	3, item Ih
Placing rock	3,643,494	CY				\$0.75	\$2,732,621	3, item Ih
F&P sand filter and gravel drain	132,390	CY				\$8.54	\$1,130,608	3, items Ii & Ij
Grouting foundation	JOB	LS	123	176	\$380,859	\$544,970	\$544,970	4, sheet 4
Drains	2,542	LF	123	176	\$7.75	\$11.09	\$28,190	4, sheet 4
Gravel on crest	1,882	CY	123	176	\$7.75	\$11.09	\$20,875	4, sheet 4
10% minor items	JOB	LS					\$4,516,582	
SUBTOTAL HUNTERS DAM							\$49,682,404	
VIII. LOGAN DAM - Earthfill and Rockfill Structure; Crest Elevation 541.3								
Total Embankment Volume	6,534,000	CY						
Excavation, all classes for foundation	370,423	CY				\$3.23	\$1,196,465	3, item Id

Table 2c
ESTIMATED COSTS
COLUSA RESERVOIR (3.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Stripping borrow pits	252,489	CY				\$1.15	\$290,362	3, item 1c
Excavation, impervious and hauling to dam (borrow)	2,520,931	CY				\$3.22	\$8,117,398	3, item 1c
Excavation, rockfines and hauling to dam (borrow)	971,568	CY	123	176	\$5.00	\$7.15	\$6,951,053	4, sheet 3
Excavation, rock and hauling to dam (borrow)	2,215,412	CY	123	176	\$5.00	\$7.15	\$15,850,099	4, sheet 3
Placing impervious	2,154,466	CY				\$0.95	\$2,046,743	3, item 1f
Placing rockfines	1,214,479	CY				\$0.75	\$910,859	3, item 1h
Placing rock	3,165,055	CY				\$0.75	\$2,373,791	3, item 1h
F&P sand filter and gravel drain	115,005	CY				\$8.54	\$982,144	3, items 1i & 1j
Grouting foundation	JOB	LS	123	176	330,847	\$473,408	\$473,408	4, sheet 4
Drains	2,208	LF	123	176	\$7.75	\$11.09	\$24,489	4, sheet 4
Gravel on crest	1,635	CY	123	176	\$7.75	\$11.09	\$18,134	4, sheet 4
10% minor items	JOB	LS					\$3,923,494	
SUBTOTAL LOGAN DAM							\$43,158,439	
IX. DIKES								
Total Embankment Volume	23,561,800	CY						
Excavation, all classes for foundation	1,784,308	CY				\$3.23	\$5,763,314	3, item 1d
Excavation, impervious and hauling to dam (borrow)	13,623,967	CY				\$3.22	\$43,869,175	3, item 1c
Excavation, sand, gravel and hauling to dam (borrow)	3,211,092	CY	123	176	\$6.65	\$9.52	\$30,554,974	4, sheet 5
Excavation, rock and hauling to dam (borrow)	5,531,685	CY	123	176	\$6.65	\$9.52	\$52,636,456	4, sheet 5
Placing impervious	11,644,346	CY				\$0.95	\$11,062,129	3, item 1f
Placing rockfines	4,013,865	CY				\$0.75	\$3,010,399	3, item 1h
Placing rock	7,903,589	CY				\$0.75	\$5,927,692	3, item 1h
F&P riprap	561,776	CY				\$31.64	\$17,774,578	3, item 1n
F&P filter blanket	1,668,775	CY				\$8.54	\$14,251,335	3, item 1i
F&P bedding for riprap	281,053	CY				\$11.79	\$3,313,618	3, item 1m
Grouting foundation	JOB	LS	123	176	\$1,880,309	\$2,690,524	\$2,690,524	4, sheet 5
10% Minor items	JOB	LS					\$19,085,419	
SUBTOTAL DIKES							\$190,834,195	
X. SPILLWAY								
Excavation, open cut, all classes	8,557	CY				\$4.03	\$34,485	3, AVG items 11a, 11la
Backfill	1,200	CY				\$8.17	\$9,804	3, item 11lf
Special compacted backfill	300	CY	128	186	\$9.30	\$13.51	\$4,054	4, sheet 5
Structural Concrete in floors and crest	485	CY				\$365	\$177,025	3, AVG items 11h, 11lc, 11ld
Structural Concrete in walls	479	CY				\$365	\$174,835	3, AVG items 11h, 11lc, 11ld
Drilling and grouting anchors	2,260	LF	128	186	\$11.60	\$16.86	\$38,095	4, sheet 5
F&I 4" dia. S.P. drains	180	LF	128	186	\$11.60	\$16.86	\$3,034	4, sheet 5

Table 2c
ESTIMATED COSTS
COLUSA RESERVOIR (3.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Riprap	200	CY				\$31.64	\$6,328	3, item In
Bedding for riprap	100	CY				\$11.79	\$1,179	3, item Im
F&I 6" dia. S.P. drains	700	LF	128	186	\$11.60	\$16.86	\$11,799	4, sheet 5
10% Minor items	JOB	LS					\$46,064	
SUBTOTAL SPILLWAY							\$506,702	
Increase spillway capacity from 250cfs to 2,500cfs								
Cost Factor = (2,500/250) ^{3/8} = 2.371	2.371							
TOTAL SPILLWAY							\$1,201,391	
XL OUTLET WORKS AT GOLDEN GATE DAM								
Excavation all classes tailrace	36,000	CY	128	206	\$4.60	\$7.40	\$266,513	4, sheet 6
Excavation, open cut	6,000	CY				\$3.38	\$20,280	3, item IIa
Excavation, tunnel	9,700	CY				\$128	\$1,241,600	3, item Vis
Excavation, gate chamber and shaft	6,300	CY				\$147	\$926,100	3, item IIc
Drilling grout holes	13,400	LF				\$18.70	\$250,580	3, item Iq
F&I grout pipe and fittings	6,700	LB	128	206	\$2.85	\$4.59	\$30,731	4, sheet 6
Hookups to grout holes	446	EA	128	206	\$57.00	\$91.73	\$40,914	4, sheet 6
Pressure grouting	13,400	SKS	128	206	\$57.00	\$91.73	\$1,229,241	4, sheet 6
Concrete in tunnel lining	7,240	CY				\$321	\$2,324,040	3, item VIIi
Structural Concrete in intake	3,950	CY				\$340	\$1,343,000	3, item VIIk
Structural Concrete in gate chamber and shaft	3,110	CY				\$340	\$1,057,400	3, item VIIk
Structural Concrete in stilling basin	3,850	CY				\$340	\$1,309,000	3, item VIIk
Structural Concrete in anchor blocks	3,000	CY				\$256	\$768,000	3, item VIIId
Metal control house	JOB	LS	128	206	\$5,700	\$9,173	\$9,173	4, sheet 6
Specially compacted backfill	800	CY	128	206	\$9.70	\$15.61	\$12,489	4, sheet 6
F&I 11x11 fixed wheel gates	116,000	LB	128	206	\$3.45	\$5.55	\$644,072	4, sheet 6
2-42" H.J. valves and controls	32,222	LB	128	206	\$3.90	\$6.28	\$202,243	4, sheet 6
2 guard gates for 42" H.J. valves	32,000	LB	128	206	\$4.30	\$6.92	\$221,450	4, sheet 6
4-6.5'x8.0' H.P. gates	564,000	LB	128	206	\$2.85	\$4.59	\$2,586,909	4, sheet 6
144" dia. penstock & manifold for H.P. gates	2,000,000	LB				\$1.65	\$3,300,000	3, item VIIc
F&I tunnel supports	288,000	LB				\$3.66	\$1,054,080	3, item IIe
Trashrack metalwork	74,000	LB				\$3.63	\$268,620	3, item VIq
F&I tower bulkhead	100,000	LB				\$3.02	\$302,000	3, item VIIn
Tunnel vent system	JOB	LS	128	206	\$80,500	\$129,555	\$129,555	4, sheet 6
Other misc. metalwork	3,000	LB				\$3.63	\$10,890	3, item VIIi
Rockbolts	27,900	LF				\$64.14	\$1,789,506	3, item VIy
Chain link fabric	23,000	SF	128	206	\$8.00	\$12.88	\$296,125	4, sheet 6
10% Minor items	JOB	LS					\$2,163,451	
SUBTOTAL OUTLET WORKS							\$23,797,961	

Table 2c
ESTIMATED COSTS
COLUSA RESERVOIR (3.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
Upsize Outlet Works for Emergency Evacuation								
Increase Outlet Works capacity from 2,100cfs to 22,000cfs								
Cost Factor = (22,000/2100) ^{3/8} = 2.413	2.413							
OUTLET WORKS COST AT GOLDEN GATE DAM							\$37,424,480	
XII. OUTLET WORKS AT LOGAN DAM								
Excavation all classes tailrace	36,000	CY	128	206	\$4.60	\$7.40	\$266,513	4, sheet 6
Excavation, open cut	6,000	CY				\$3.38	\$20,280	3, item IIa
Excavation, tunnel	8,440	CY				\$128	\$1,080,320	3, item VIa
Excavation, gate chamber and shaft	6,300	CY				\$147	\$926,100	3, item IIc
Drilling grout holes	11,700	LF				\$18.70	\$218,790	3, item Iq
F&I grout pipe and fittings	5,800	LB	128	206	\$2.85	\$4.59	\$26,603	4, sheet 6
Hookups to grout holes	388	EA	128	206	\$57.00	\$91.73	\$35,593	4, sheet 6
Pressure grouting	11,700	SKS	128	206	\$57.00	\$91.73	\$1,073,292	4, sheet 6
Concrete in tunnel lining	6,300	CY				\$321	\$2,022,300	3, item VIIi
Structural Concrete in intake	3,950	CY				\$340	\$1,343,000	3, item VIIk
Structural Concrete in gate chamber and shaft	3,110	CY				\$340	\$1,057,400	3, item VIIk
Structural Concrete in stilling basin	3,850	CY				\$340	\$1,309,000	3, item VIIk
Structural Concrete in anchor blocks	3,000	CY				\$256	\$768,000	3, item VIId
Metal control house	JOB	LS	128	206	\$5,700	\$9,173	\$9,173	4, sheet 6
Specially compacted backfill	800	CY	128	206	\$9.70	\$15.61	\$12,489	4, sheet 6
F&I 11x11 fixed wheel gates	116,000	LB	128	206	\$3.45	\$5.55	\$644,072	4, sheet 6
2-42" H.J. valves and controls	32,222	LB	128	206	\$3.90	\$6.28	\$202,243	4, sheet 6
2 guard gates for 42" H.J. valves	32,000	LB	128	206	\$4.30	\$6.92	\$221,450	4, sheet 6
4-6.5'x8.0' H.P. gates	564,000	LB	128	206	\$2.85	\$4.59	\$2,586,909	4, sheet 6
144" dia. penstock & manifold for H.P. gates	1,740,000	LB				\$1.65	\$2,871,000	3, item VIIc
F&I tunnel supports	250,600	LB				\$3.66	\$917,196	3, item IIe
Trashrack metalwork	74,000	LB				\$3.63	\$268,620	3, item VIq
F&I tower bulkhead	100,000	LB				\$3.02	\$302,000	3, item VIh
Tunnel vent system	JOB	LS	128	206	\$70,000	\$112,656	\$112,656	4, sheet 6
Other misc. metalwork	3,000	LB				\$3.63	\$10,890	3, item VIIi
Rockbolts	24,300	LF				\$64.14	\$1,558,602	3, item VIy
Chain link fabric	23,000	SF	128	206	\$8.00	\$12.88	\$296,125	4, sheet 6
10% Minor items	JOB	LS					\$2,016,062	
SUBTOTAL OUTLET WORKS							\$22,176,678	
Upsize Outlet Works for Emergency Evacuation								
Increase Outlet Works capacity from 2,100cfs to 22,000cfs								
Cost Factor = (22,000/2100) ^{3/8} = 2.413	2.413							
OUTLET WORKS COST AT LOGAN DAM							\$33,312,325	

Table 2c
ESTIMATED COSTS
COLUSA RESERVOIR (3.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
XIII. LOGAN PUMPING - GENERATING PLANT (Located at Logan Dam)								
(Q=5,000cfs, TDH=332, eff=75%, HP=251,116)								
Pumping-Generating Plant Complete	JOB	LS				\$230,308,000	\$230,308,000	2
SUBTOTAL LOGAN PUMPING - GENERATING PLANT							\$230,308,000	
XIII. LOGAN PUMPING/GENERATING PLANT SWITCHYARD								
Station Equipment, Electrical								
Transformer, 3 Phase, 65 MVA, 230/6.9 kv	1	EA	123	190	\$665,721	\$1,028,350	\$1,028,350	4, sheet26
230-kv Line Bay, 10,000 MVA	3	EA	123	190	\$421,000	\$650,325	\$1,950,976	4, sheet26
230-kv Bus-Tie Bay, 10,000 MVA	1	EA	123	190	\$371,000	\$573,089	\$573,089	4, sheet26
Coupling Capacitor, (w/potential device)	5	EA	123	190	\$7,800	\$12,049	\$60,244	4, sheet26
Carrier equipment	2	EA	123	190	\$20,000	\$30,894	\$61,789	4, sheet26
Telemetry and supervisory control	JOB	LS	123	190	\$118,936	\$183,722	\$183,722	4, sheet26
SUBTOTAL SWITCHYARD							\$3,858,169	
Increase capacity from 2,100cfs to 5,000cfs								
Cost Factor = (5,000/2100)6/10 = 1.683	1.683							
OUTLET WORKS COST AT LOGAN DAM							\$6,493,299	
XIV. LOGAN CANAL								
Earthwork	8,976	LF				\$346	\$3,105,696	2
Concrete Lining	8,976	LF				\$139	\$1,247,664	2
SUBTOTAL LOGAN CANAL							\$4,353,360	
XV. LOGAN FOREBAY DAM								
Total Embankment Volume	156,850	CY						
Excavation, all classes for foundation	8,892	CY				\$3.23	\$28,721	3, item Id
Stripping borrow pits	6,061	CY				\$1.15	\$6,970	3, item Ic
Excavation, impervious and hauling to dam (borrow)	60,515	CY				\$3.22	\$194,860	3, item Ic
Excavation, rockfines and hauling to dam (borrow)	23,323	CY	123	176	\$5.00	\$7.15	\$166,861	4, sheet 3
Excavation, rock and hauling to dam (borrow)	53,181	CY	123	176	\$5.00	\$7.15	\$380,485	4, sheet 3
Placing impervious	51,718	CY				\$0.95	\$49,132	3, item If
Placing rockfines	29,154	CY				\$0.75	\$21,865	3, item Ih
Placing rock	75,978	CY				\$0.75	\$56,983	3, item Ih
F&P sand filter and gravel drain	2,761	CY				\$8.54	\$23,577	3, items Ii & Ij
Grouting foundation	JOB	LS	123	176	7,942	\$11,364	\$11,364	4, sheet 4
Drains	53	LF	123	176	\$7.75	\$11.09	\$588	4, sheet 4
Gravel on crest	39	CY	123	176	\$7.75	\$11.09	\$435	4, sheet 4
10% minor items	JOB	LS					\$94,184	
SUBTOTAL LOGAN FOREBAY DAM							\$1,036,027	

Table 2c
ESTIMATED COSTS
COLUSA RESERVOIR (3.3 MAF ALTERNATIVE)

DESCRIPTION	QUANTITY	UNIT	USBR INDEX JAN. 80	USBR INDEX OCT. 96	UNIT COST JAN. 80	UNIT COST OCT. 96	TOTAL COST OCT. 96	COST REFERENCE
XVL SITES-COTTONWOOD ELVERTA #2 LOOP								
Clearing Land	JOB	LS	126	217	\$4,460	\$7,681	\$7,681	4, sheet27
Towers and Fixtures	JOB	LS	126	217	\$471,380	\$811,821	\$811,821	4, sheet27
Conductors and Devices	JOB	LS	126	217	\$250,160	\$430,831	\$430,831	4, sheet27
SUBTOTAL #2 LOOP							\$1,250,333	
SUBTOTAL							\$818,000,000	
CONTINGENCIES @ 20%							\$164,000,000	
ESTIMATED CONSTRUCTION COST							\$982,000,000	
ENGR, LEGAL, AND ADMIN @ 35%							\$344,000,000	
ESTIMATED CAPITAL COST							\$1,330,000,000	
ESTIMATED CAPITAL COST RANGE								
LOW (-10%)							\$1,200,000,000	
HIGH (+15%)							\$1,530,000,000	
COST ESTIMATE DOES NOT INCLUDE FUNKS DAM ENLARGEMENT.								

Footnote:

*LS=lump sum; AC=acre; MI=mile; CY=cubic yard; LF=linear foot; LB=pound; SF=square foot; EA=each

Cost References:

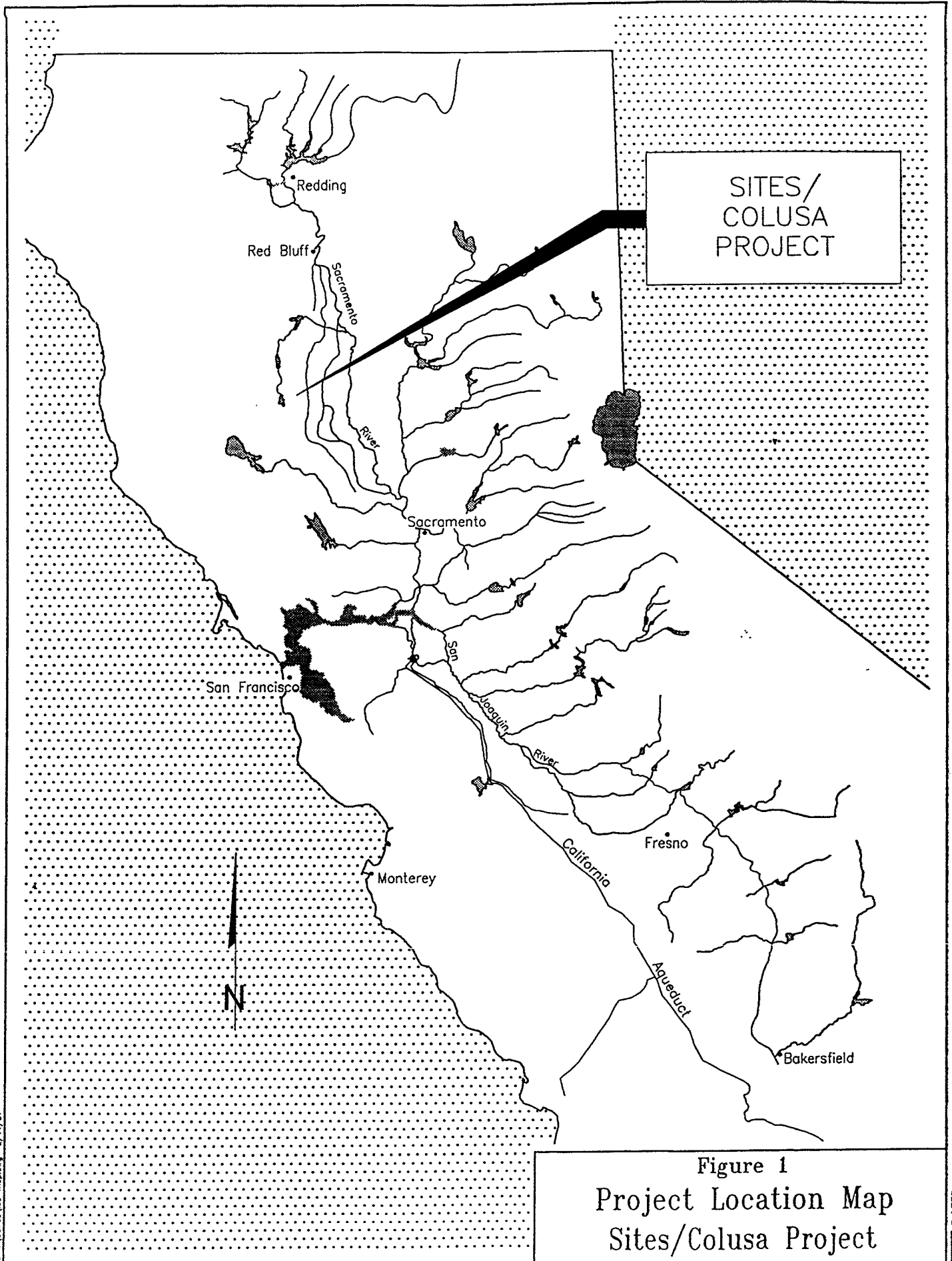
1. U.S. Bureau of Reclamation, Land Resources Branch, Graham McMullen, February 1997.
2. Cost developed by Bookman-Edmonston Engineering.
3. California Department of Water Resources, *Los Banos Grandes Facilities Report, Appendix A: Designs and Cost Estimates*, December 1990.
4. U.S. Bureau of Reclamation, *Appraisal Design Criteria and Cost Estimate Appendix, West Sacramento Canal Unit, Sacramento River Division, CVP*, September 1980.

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Table 3
SUMMARY OF ESTIMATED COSTS
SITES/COLUSA RESERVOIR

Cost Item	Estimated Cost (\$Millions)		
	1.2 maf	1.9 maf	3.3 maf
Rights of Way	\$24.4	29.1	58.8
Relocation of Existing Property	13.7	16.4	32.7
Clearing Reservoir	0.8	0.8	1.5
Access Road	2.5	3.0	6.1
Dams and Dikes	40.8	137.5	363.6
Spillway	0.4	0.5	1.2
Outlet Works	50.0	57.4	110.9
Generating Plants	212.3	234.8	230.3
Generating Plant Switchyard	6.5	6.5	6.5
Logan Canal and Forebay Dam			5.4
Sites-Cottonwood Elverta #2 Loop	0.6	0.6	1.3
SUBTOTAL	349	484	818
Contingencies (20%)	70	97	164
ESTIMATED CONSTRUCTION COST	419	581	982
Engineering, Legal, and Project Administration (35%)	417	203	344
ESTIMATED TOTAL CAPITAL COST	566	784	1330
Capital Cost Range (minus 10% - plus 15%)	\$509 - \$ 651	\$706 - \$902	\$1,200 - \$1,530

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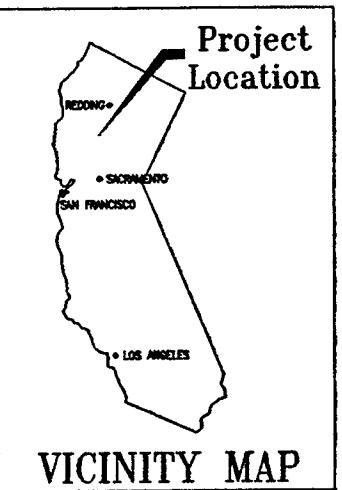
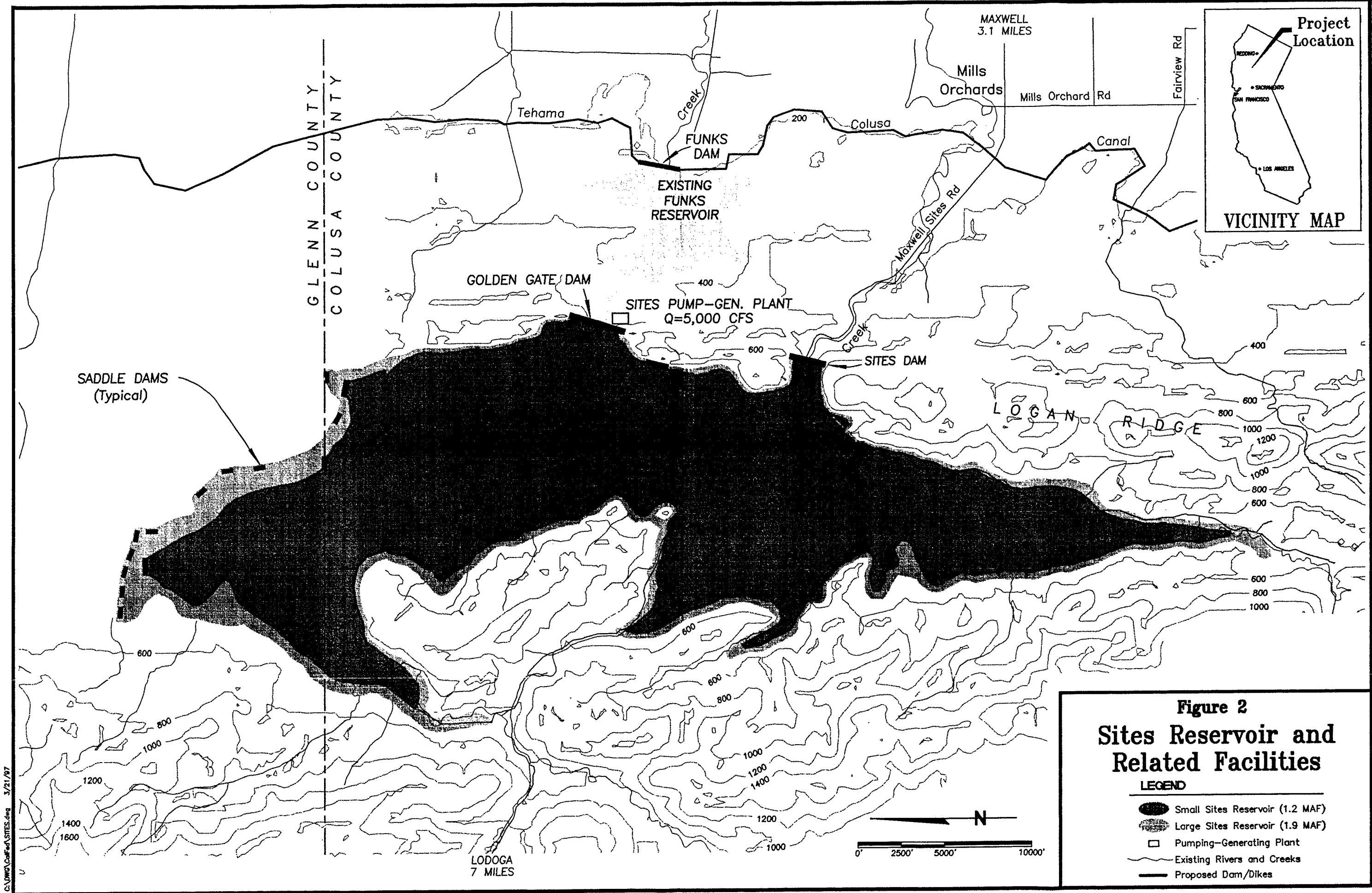


Figure 2
Sites Reservoir and Related Facilities

- LEGEND**
- Small Sites Reservoir (1.2 MAF)
 - Large Sites Reservoir (1.9 MAF)
 - Pumping-Generating Plant
 - Existing Rivers and Creeks
 - Proposed Dam/Dikes

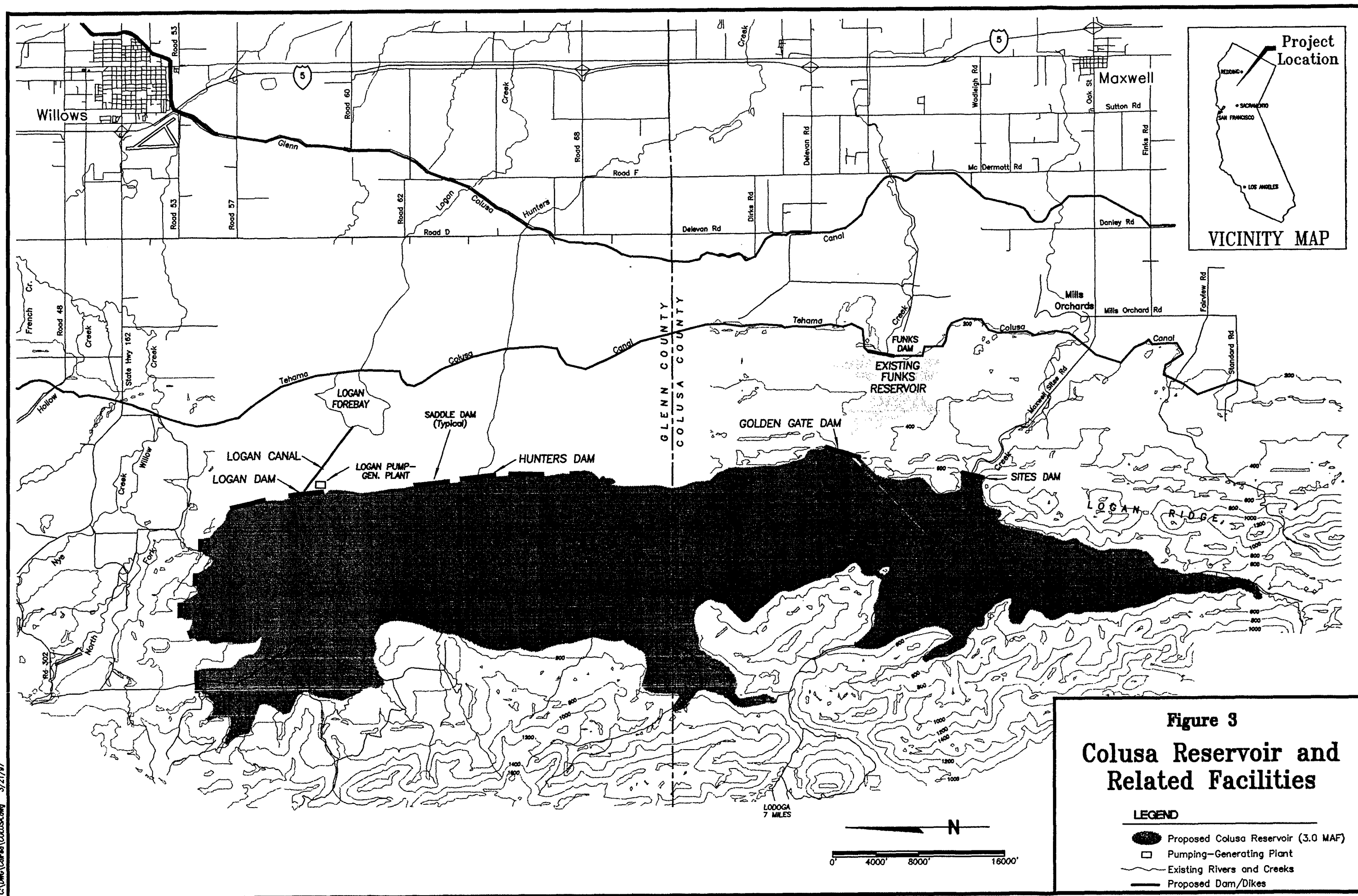


Figure 4
AREA-CAPACITY CURVES
SITES RESERVOIR

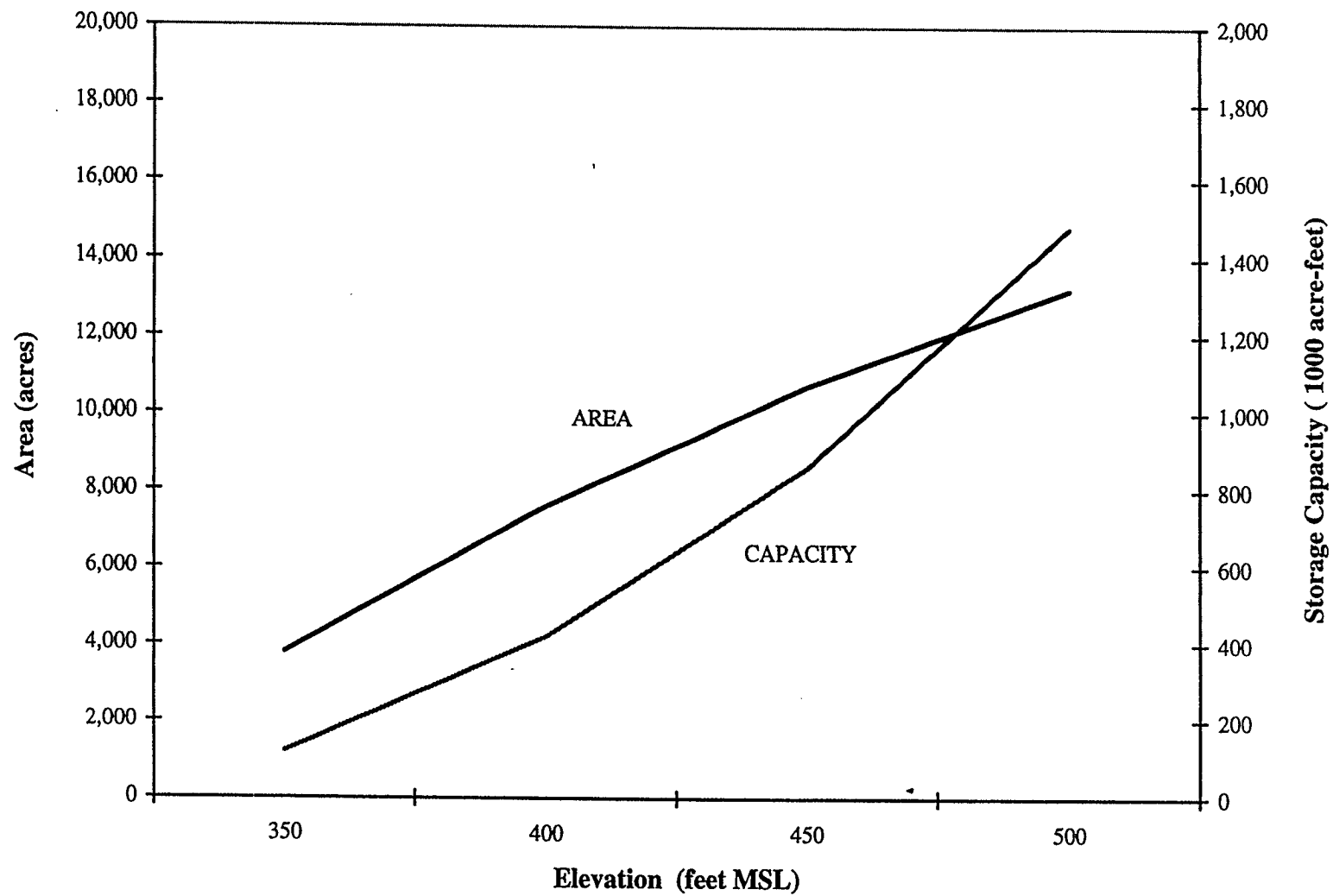
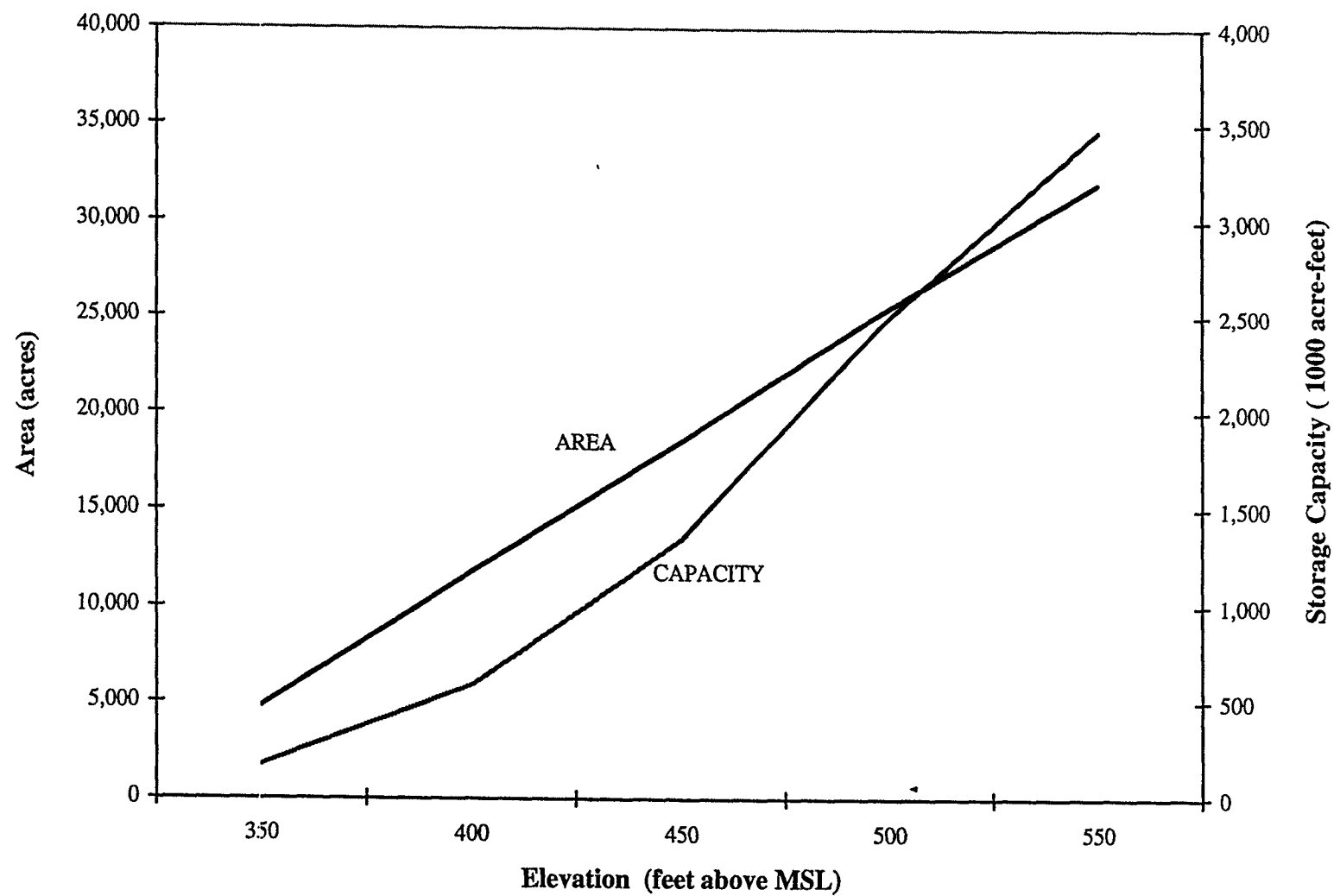


Figure 5
AREA-CAPACITY CURVES
COLUSA RESERVOIR



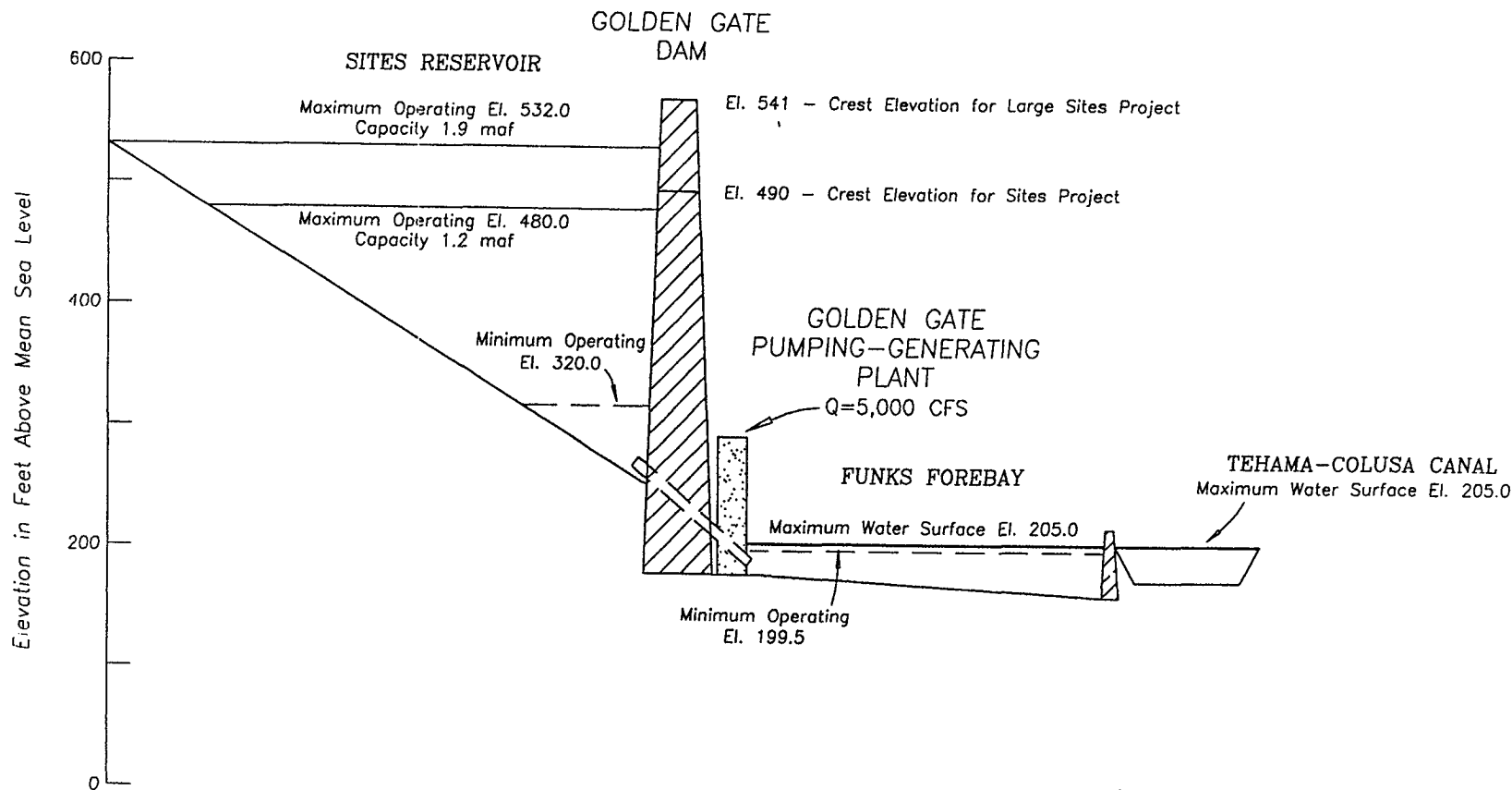


Figure 6
 Sites Reservoir
 and Related Facilities
 Schematic Profile

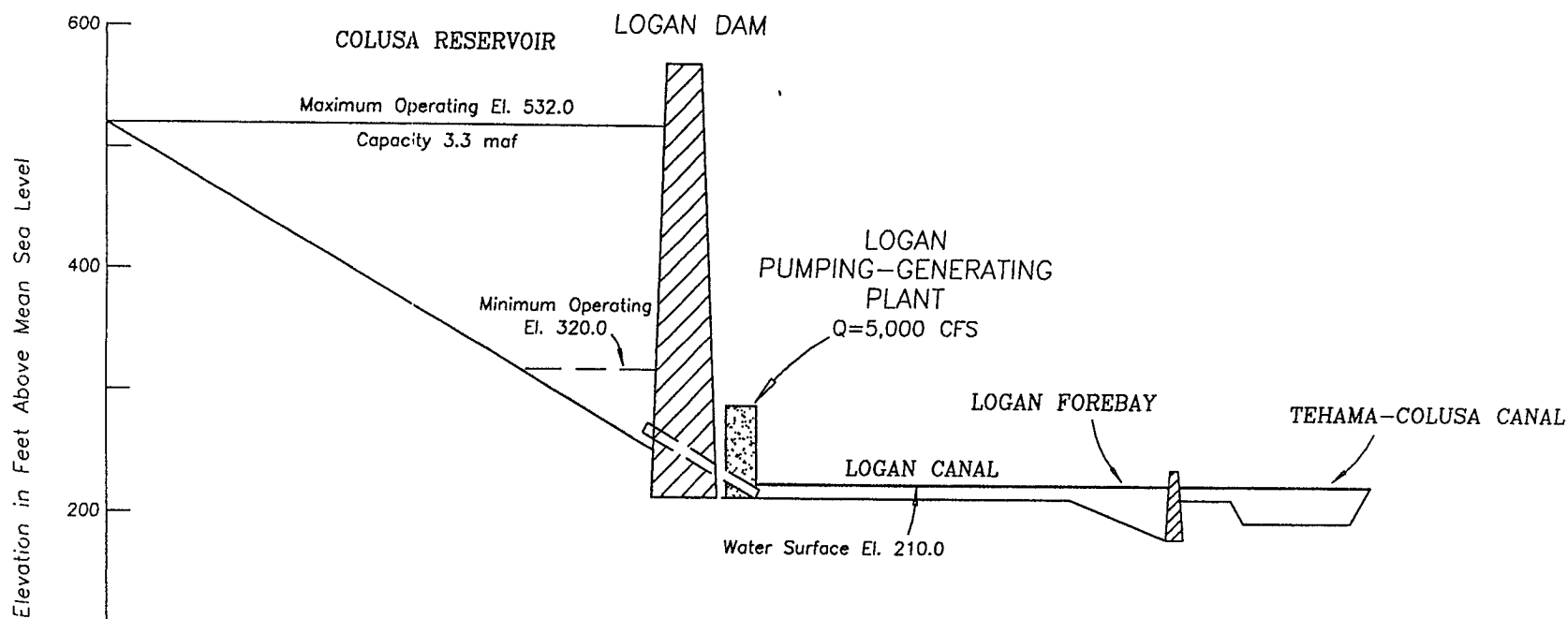


Figure 7
Colusa Reservoir
and Related Facilities
Schematic Profile